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Mine Safety Education and Training Seminar

Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, Pa., Dec. 9, 1980, Springfield, Ill., Dec. 12, 1980, and Reno, Nev., Dec. 16, 1980

Compiled by Staff—Pittsburgh Research Center

UNITED STATES DEPARTMENT OF THE INTERIOR

United States. Bureau of Mines.

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James G. Watt, Secretary

BUREAU OF MINES
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ABSTRACT

Research personnel from the Bureau of Mines, a representative of the Mine Safety and Health Administration, and research contractors for the Bureau of Mines met with other Government and industry representatives at three seminar locations in December 1980 to discuss the findings and products of Bureau research on mine safety training. The research program is aimed at providing assistance to the mining community in its efforts to reduce industrial-type, human-error accidents through research establishing performance based methods and media for employee training. Research emphasis is directed toward development of baseline materials and instructional models; development of methods for structuring and evaluating health and safety, supervisory, and occupational training; and the continued investigation and application of current learning and simulation technology that could significantly enhance the effectiveness of training opportunities.

INTRODUCTION

The following papers in this report describe a major aspect of the Bureau of Mines human factors research program. Training combines with ergonomics research in addressing industrial-type, human-error injuries. The Bureau program was implemented in 1973, shortly after the Coal Mine Health and Safety Act became Public Law 91-173.

The research program is directed toward assisting the mining community in structuring, formalizing, and evaluating training investments. The scope of current efforts entail the development of guidelines for the conduct and evaluation of mine training. Baseline instructional material and evaluation techniques have been developed for a number of mining tasks and safety training activities. The research goal is to develop and validate performance objectives. Achievement of this goal requires a systematic approach to the analysis and use of a needs assessment, the specification of instructional objectives, the use of controlled training experiences (both classroom and on-the-job training), and the identification of performance criteria. Once evaluation procedures are established, the findings can be used to improve the training process. These development efforts are in direct support of MSHA regulations (30 CFR, Part 48) governing the conduct of new miner, annual refresher, and new task training.

This phase of training research is short term and will result in development of performance criteria for the wide range of training activities conducted by the mining community. Concurrent with these ongoing and finite developmental efforts, long-term research activities have been devoted to investigating innovative training and evaluation methods that address the unique environmental and industrial safety problems applicable to mining. Examples of this work include preliminary research in the development of specialized training equipment, the use of observational research for evaluating mine health and safety training, and development of benefit-cost models providing information for localized training investments.

Open File Report (OFR) references in the proceedings listed as available from NTIS may be obtained from the National Technical Information Service, Springfield, Va. 22161, and are also available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn.,, Bruceton and Pittsburgh, PA., and Spokane, Wash.; Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; the National Mine Health and Safety Academy, Beckley, W. Va., and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.

Throughout the proceedings, mention of trade names is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

ACKNOWLEDGMENTS

Appreciation is extended to the speakers and the many people who helped with these seminars. Special credit is due to J. T. Bernard, operations research analyst, and W. J. Wiehagen, supervisory industrial engineer, Industrial Safety and Training Systems, Pittsburgh Research Center, for planning and implementing the seminar.

HUMAN FACTORS AND INDUSTRIAL SAFETY

by

James M. Peay[1]

ABSTRACT

The focus of the paper is to discuss human factors, its potential role in reducing "human error" type injuries, and implicit assumptions about human behavior impacting upon workplace design.

A brief overview of current human factors (ergonomics) research will demonstrate the complementary objectives that ergonomics and training serve to enhance safety.

INTRODUCTION

In mining, as in other industries, a major concern focuses on maximizing productivity and worker safety. Technology has been brought to bear on this problem and has produced impressive results over the past 25 years. With the introduction of walking draglines, over 200-ton-haulers, continuous and long-wall mining, and other systems, daily production tonnage has greatly increased. The safety and health of the miner has also been improved substantially.

In the last few years, however, we have witnessed a disturbing turnaround in this trend. A nagging presence of unacceptable high levels of worker fatalities and injuries still persists. Technology itself has been unable to remedy these problems. Hence, we as an industry must look more closely at the people in the production system. We must look at the human factors involved.

People are the drivers of all our technology. It is people who operate machines, make decisions, and feed and maintain the equipment that results in higher production and improved safety. It is people who make technology run.

Two critical components of this symbiosis between man and machines that allow technology to roll along smoothly and safely are: human factors engineering and training. These components complement each other and the technology itself, resulting in better overall man-machine performance. The contributions of training to productivity and safety will be covered in other papers in this seminar. The focus of this paper will be on what human factors is, and what contributions it can make to productivity and safety that complement the contributions of training. Before defining human factors and discussing its potential contributions, it will be worthwhile to briefly discuss some assumptions about human behavior that are implicit in our current technology.

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Unfounded Assumptions About Human Behavior

Technology, in its relentless pursuit of production, has made a number of assumptions about human behavior. Many of these assumptions have proven to be well-founded. Several, however, have proven to be erroneous. As technology itself becomes increasingly more complex and expensive, the consequences of these erroneous assumptions become more costly. Consider several of these unfounded assumptions.

Assumption 1.--All People Are Created Equal

Years of research and trial-and-error experience have, in fact, shown that all people are not created equal. People differ greatly with respect to:

Physical size and strength.
Ability to follow instructions.
Ability to solve problems.
Eye-hand coordination.
Physical endurance.
Attention to detail.
Motivation.
Overall competency to perform jobs.

Technology erroneously assumes, for example, that competent people will operate and maintain the system. As we all know, that simply is not true. This assumption has become even more untenable as the demand for competent people has exceeded the supply. This suggests that we are going to have to design equipment that is easier to operate and to maintain.

Assumption 2.--People Perform as Trained

Technology erroneously assumes that people will perform the way they were trained to perform. If this were so, all our problems would be solved. With any amount of reasonable training, people still forget and make mistakes. In some cases, people deliberately do not follow instructions and procedures. We need only look at compliance with the 55-mph speed limit to see this. This means we must do a better job of designing equipment, procedures, and training to minimize the possibility, or impact, of undesirable human performance.

Assumption 3.--People Are Infinitely Adaptable

Technology erroneously assumes that people are adaptable and will get used to anything with a little practice. We know that even our most experienced operators and maintenance personnel still make mistakes. This assumption of adaptablility has stood in the way of standardization: "It doesn't matter if two machines are operated or maintained differently--people will get used to it."

Assumption 4.--Operators and Maintainers Are All Design Engineers

Technology erroneously assumes that operators and maintainers look, think, and act like the engineers who design the system. One need only to have tried

to put together one of those new children's toys by following the directions packed into every box. It requires an engineering degree!

In part, because of this assumption, the human operator and maintainer have been largely ignored in the design of systems. As a result, an increased level of demands has been placed on the worker.

Assumption 5.--There Are No Other Demands on the Users

There are many environmental demands placed on users including noise, climate, glare, dust, and vibration. Even equipment factors have placed demands on the worker: For example, cramped workspace, controls that are easily confused and hard to reach, dials that are hard to read and don't present the information that is needed in a usable format, and difficult decisions to be made with little time to make them. Demands for productivity and safety are also factors that increase the overall load put on the worker.

When demands are placed on people they begin to make mistakes. The vast majority of mistakes, however, do no harm because the system either compensates by itself or, more often, allows the operators time to correct the error. Mistakes are bound to occur and do so with a frequency that some find disturbing. Even among commercial airline pilots, considered perhaps the best prepared of modern technicians, experts estimate each pilot has an average of one or two errors, although minor and correctable, per hour.

People can adapt to increased demands, for a little while, as long as the overall level of demand is low. Under time pressure, demands can mount up fast and overload the person. The question is how can we reduce or minimize the demands placed on the individual. One approach is through training. The philosophy behind training is that you can design the person to fit the job. But, as we know, people don't always perform like they were trained to perform. People forget and this is especially true when they have to respond quickly in a stressful situation. For example, shuttle car drivers know that when driving forward, turning the wheel clockwise turns the vehicle to the right--as you would expect. But when driving backwards, the wheel must be turned counterclockwise to turn right. Operators do this every day--usually with no problems. In a panic situation, however, they will tend to forget and turn the wheel in the expected clockwise direction to turn right--even if they are headed in the backward direction.

In addition to training, another approach to reducing the demands placed on the worker is through the prudent application of human factors. The philosophy behind human factors, as compared with training, is that you can design the job and/or equipment to fit the person. In other words, it's easier to bend metal than it is to twist arms. Hence, we design simple procedures, reduce physical and sensory demands, simplify decisions, and design equipment to take advantage of human capabilities. For example, in our shuttle car example, we could design the vehicle so that clockwise rotation of the steering wheel always resulted in a right turn no matter which direction the shuttle car was going.

What is Human Factors?

It is important to stress that human factors and training are complementary. Good design can reduce the requirements for training. Neither approach can completely overcome the need for the other. The idea is to balance the two and maximize the benefits for the minimum cost.

This is why, of course, we are discussing human factors at a technical seminar on training.

Human factors is the systematic application of relevant information about human characteristics, abilities, expectations, and behaviors to the design of machines, tools, facilities, procedures, and environments that people use. The goal of human factors is to enhance system performance and the health and safety of people using the system. The human-factors approach is to design systems that are compatible with human beings' physical characteristics, information processing capabilities, perceptual and motor abilities, and their expectations and behavior patterns. Human factors attempts to translate these into specific design requirements.

Human factors actually got started during World War II when it became apparent that the new sophisticated equipment was exceeding the operators' capabilities. Aircraft were, at the time, the most sophisticated systems and it was there that the problems showed up first. Control sticks with identical knobs on each were placed very close together in the aircraft cockpit. It was not uncommon for a pilot to reach for the landing gear control and lower the flaps instead, sending the plane into an abrupt landing, usually somewhat short of the field.

In one World War II aircraft, the auxiliary fuel tank switch was located under the seat between the pilot's legs. In the replacement aircraft, the fuel tank jettison switch was located in the same place. Seven people were killed attempting to switch to auxiliary tanks in the replacement model. Without fuel tanks, the plane has a glide angle of a tool box. Altimeters were routinely misread by 1,000 feet--usually in the hazardous direction, that is, thinking they were higher than they really were.

At first, the accidents were blamed on pilot error, but often the errors were made by pilots with thousands of hours of flying time. Nor were pilots the only ones making mistakes. In the 1950's, there was a succession of unexplained crashes. It was discovered that during routine maintenance, workers had reversed the wires that controlled the wing flaps. The flaps would go up when the pilot intended for them to go down. It wasn't human error, but rather design error that was the culprit. By shape coding controls, standardizing control and display placement, and redesigning displays, most of these errors have been reduced or eliminated in today's aircraft.

Since the war, human factors has branched out into all sorts of civilian industries. Xerox, for example, employs human factors people in the design of its copiers and word processors. Eli Lilly and Kodak employ human factors people to design their assembly line work stations. Several human factors

studies have been made of nuclear power plant control rooms and many serious human factors deficiencies were found--some of which contributed to the Three-Mile Island crisis. Several of these design deficiencies have their counterparts in the design of mining equipment today:

1. Lack of control coding. Nuclear power plant control rooms are a virtual forest of identical control knobs. The only way to tell them apart is to read the labels, which is not much help if quick action is required. In one control room, draft beer dispenser handles were placed on some controls for quick identification.

Figure 1 shows a similar situation, but on a smaller scale. These are continuous miner controls, all identical, all in a row.

FIGURE 1. - Controls on a continuous miner showing lack of control coding.

2. In some nuclear power plants, one panel is the reverse of the other. What is on the left side of one is located on the right side of the other. As one operator puts it: "You automatically head in the wrong direction."

Many mining machines have mirror image controls on opposite sides of the machine. One specific 150-ton-capacity hauler, used in surface mining, has the retarder and brake pedals to the left of the accelerator pedal. On another 150-ton-capacity hauler, however, it is reversed, the retarder and brake are on the right of the accelerator. In an emergency the operator is apt to hit the wrong pedal.

At five nuclear power plants, at least 41 incidences of operator error were traced to poor application of human factors design principles. The consequences included $750,000 in equipment damage, a $500,000 loss of revenue, and the release of radiation to the atmosphere. In the

mining industry, we can only guess about the consequences to human life and property caused by poor human factors design.

Human Factors in Mining

We, of course, cannot hope to review all of the human factors problems in mining, nor can we review all of the Bureau's human factors related research. One purpose here is to provide a sample of the sorts of problems that exist and the approaches being taken to overcome them.

Failure To Use Safety Equipment

People don't always do what they are trained to do, or should do, in a situation. We often weigh the costs and benefits of taking some action, and as the perceived costs outweigh the perceived benefits, we tend not to take the action. Workers often do not use safety equipment because it is inconvenient, it's bulky, it's uncomfortable, and it interferes with their work. For example, between 1974 and 1978, in metal and nonmetal mining alone, 21 people working near water without wearing a life vest drowned. There are, of course, many reasons why a particular person doesn't wear a life vest or a safety line. One reason, however, is because the equipment is not designed to be compatible with the user during his normal work activities.

Life vests are bulky, weigh about 3 pounds, are uncomfortable and hot to wear, and interfere with the wearers as they go about their normal work activities. The basic design was developed in the 1940's. Designing a vest that is easy to put on, conforms more to the physical characteristics of the workers, and allows more freedom of movement, should increase the frequency of use, because it reduces the cost to the worker of wearing it.

Failure To Control Equipment

Failure to control equipment is a major cause of injuries and fatalities in mining. Between 1975 and 1976, 13 percent of all machinery injuries in metal and nonmetal mining were attributed to "failure to control equipment." Fifty-eight percent of all loading machine fatalities (1975-77) and 11 percent of all slusher related injuries (1970-78) were also caused by failure to control equipment.

There are, of course, many reasons for an operator to lose control of equipment, it could be a mechanical failure, but often it is not. Often the design of the equipment increases the probability that operators will lose control of it. Some of the generic human factors problems which undoubtedly contribute to loss of control accidents are:

1. Improper control layout.

2. Improper control functioning.

3. Lack of control coding.

4. Lack of standardization.

1. Improper control layout. Figure 2 shows a roof bolter operator trying to reach around the machine to control the drill while holding the steel steady. There are some controls he can't reach, especially if quick action is called for. Currently, there is some discussion regarding the pros and cons of hands-on drilling.

2. Improper control functioning. People come to a situation with certain built-in expectations about how controls are operated. For example, to turn on a light, we flip the switch up. To increase the volume of a radio we turn the knob clockwise. Some mining equipment, however, is designed so that control motions are opposite to what would be expected. We already mentioned the case of shuttle cars that steer in the opposite direction when heading backwards.

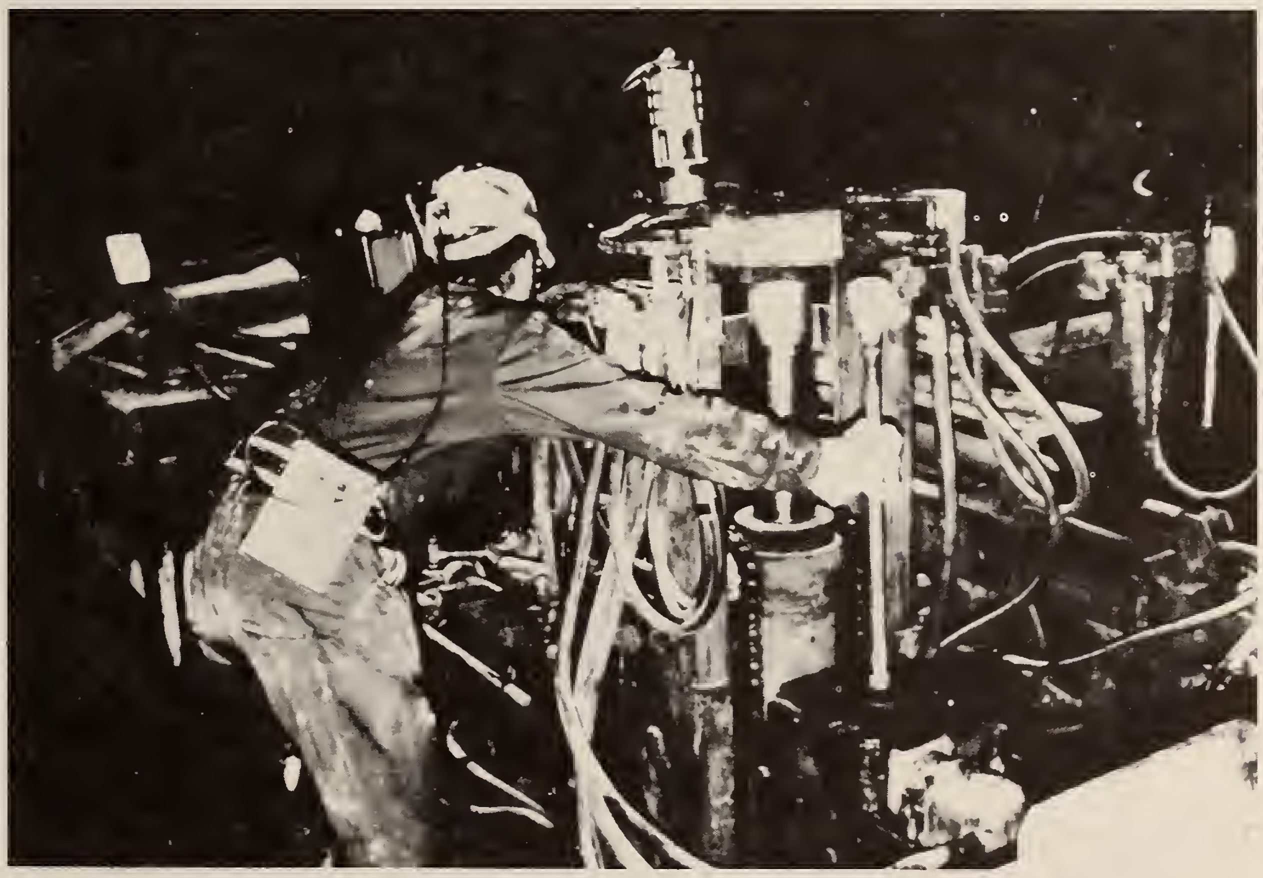

FIGURE 2. - Roof bolter operator engaged in hands-on drilling.

Under most situations the operator will do it correctly, and if not, he will have time to correct his error. In an emergency situation, however, people will tend to revert to stereotype behavior.

3. Lack of control coding. We saw an example of this in figure 1. Figure 3 shows how some workers attempted to improve the design. Notice the added electrical tape to the middle handle to help distinguish this control from the others. It's not as elegant as the use of draft beer dispenser handles, but then this isn't a nuclear power plant control room.

FIGURE 3. - Roof bolter controls with electrical tape to help distinguish one handle from another.

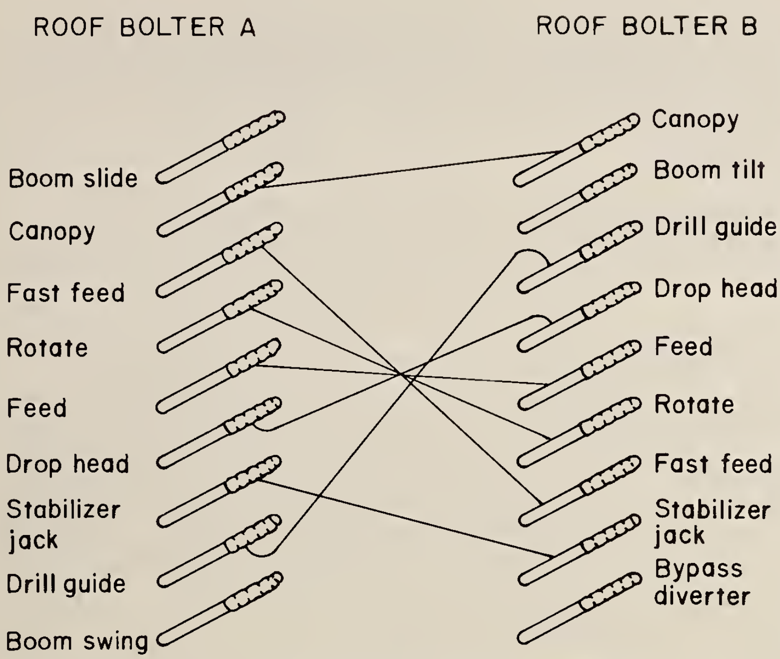

FIGURE 4. - Two control layouts from different roof bolters, illustrating the lack of standardization.

4. Lack of standardization. We saw an example of this with the 150-ton-capacity haulers and the reversed pedals. Figure 4 shows a schematic picture of the controls from two roof bolters with the function of each control marked. Notice the number of crossovers. It is entirely possible for both machines to be in the same mine, and operated by the same person.

These types of problems (improper control layout and functioning, and lack of control coding and standardization) are undoubtedly contributing to accidents and injuries in the mining industry. The Bureau has sponsored several R&D studies aimed at improving the operator's work station and control layout on several types of mining machines. A current Bureau project is aimed at developing standardized controls for roof bolters. The project will develop a prototype cab and field test it under actual mining conditions.

In the past, mining equipment design has been notorious for its lack of concern for the human operator. There has been a preoccupation in the industry with hardware systems--bigger, faster, and meaner. For years we have been relying on "operator adaptability" to overcome design deficiencies. This is changing with the greater emphasis being placed on human factors by the Bureau of Mines and Mining Safety and Health Administration (MSHA). Mining equipment manufacturers are also beginning to recognize the importance of designing machines that are compatible with the humans that must operate and maintain them.

Bureau of Mines Human Factors R&D

The Bureau's human factors research effort began in 1971 with the funding of a major survey that was designed to identify human factor problems in the underground bituminous coal mining industry. The survey was limited to underground coal due to the pressing problem in that environment and because the 1969 act mandated that research be undertaken in the underground coal mining industry. From this modest beginning in 1971, the Bureau's program has expanded until today more than 25 research efforts are either underway or soon to be started, and numerous other efforts have been completed.

Much of the past work is summarized in an Information Circular entitled "Bibliography: Human Factors in Mine Safety." This circular will soon be available. The areas of human factors reported in this circular are:

1. Underground mining machinery.

    a. Standardization of controls.

    b. Machine canopies.

    c. Optimized operator compartments.

    d. Inherently safe mining systems.

2. Surface mining machinery.

3. Miner training.

4. Organizational and behavioral factors.

5. Miscellaneous studies.

Each study is reported in the following manner:

1. Name of researcher.

2. Titles of research.

3. Purpose.

4. Procedure.

5. Results.

It will not be possible to present in-depth and extensive summaries of all completed Bureau human factors efforts, however, a few examples of the many studies reported in the Information Circular would be instructive.

Effects of Organizational Climate and Policy in Coal Mine Safety

This study was designed to explore the contribution of organizational climate and management practices to injury experience in underground coal mines.

A survey was conducted of relevant literature, and six general hypotheses were developed on the basis of previous findings. The hypotheses concerned the influence of the following factors on unsafe behavior and injuries: management planning, worker morale, worker responsibility and autonomy, and worker safety attitudes and knowledge.

Based on these hypotheses, an extensive questionnaire was developed to assess 27 factors, 21 of which dealt with organizational climate and with safety-related worker attitudes.

A cross-lagged panel design was used in which miners from 22 mines completed the questionnaire on two occasions. On each occasion, every questionnaire was scored for internal consistency, and those that were found inconsistent were removed. The responses for each questionnaire item were averaged across miners within each mine.

In addition to the survey, other questionnaires were administered to the mine superintendent and the state inspector who regularly inspected that mine. Interviews were also conducted with the mine superintendent, face foremen, and safety committee members at each mine.

In general, the results strongly support the hypothesis that climate and management practice have a causal effect on the incidence of disabling injuries. Specifically, it appears that when decisions are decentralized, when management is flexible and innovative in trying new procedures and programs, and when morale is high, disabling injuries decrease. As injuries increase, feedback, continued employee development, and consistency of orders improve and production pressure is reduced.

Personal Equipment in Low Coal

The purpose of this project was to explore alternative designs of personal equipment items used in low coal from a human factors orientation. A survey of the personal equipment literature was produced. Six individual studies were conducted using laboratory, simulation, and actual in-mine field testing. A 420-ft^2, low-seam-mine simulator was built for testing personal equipment concepts.

Some of the conclusions reached were:

1. Retroreflective armbands, belt, self rescuer, and battery pack increases detectability of miners in the periphery of the visual field by almost 100 percent over the current cap-lamp only situation.

2. Incorporating small sections of coiled cord into the cap-lamp cord reduces snagging hazards and allows the wearer more time to respond to a snag before the full force is delivered to the helmet.

3. Changes in weight of the battery pack affect locomotion times more than do changes in size of battery pack.

4. Padding can be added to the palm of work gloves without reducing manual dexterity.

5. Low-profile helmets are bumped approximately 25 percent less often than the high-profile helmets currently worn by most miners in low seams.

In addition, an improved knee pad incorporating an air cushion was developed and field tested. A new slip-resistant rubber boot sole was also designed and field tested.

Visibility Requirements for Shuttle Car and Continuous Miner Operations

The purpose of this project was to determine the visibility requirements, and current field of visibility for shuttle car and continuous miner operators. Site visits were made to 12 mines and interviews held with equipment operators. From these, a comprehensive list of visual needs was compiled and each need was rated on importance. The location of each in the visual field was identified. From this information, visibility envelope requirements were recommended.

The existing fields of visibility on two shuttle cars and two continuous miners were recorded with a photogoniometer and were compared with the proposed visibility envelope requirements.

Human Factors Problem Identification in Surface Mines

The objectives of this project include the conduct of an extensive review of coal and metal-nonmetal surface mining operations to identify significant human factors, ergonomic, and organization problems, and to rank these problems in terms of their criticality to the industry. In addition, recommendations will be developed for additional research leading to cost-effective resolution of these problems or problem areas.

The project was organized into three phases. Phase I activities included the conduct of an extensive analysis of MSHA Health and Safety Analysis Center and other accident data in an effort to identify possible man-machine environment interface problems. In addition, a comprehensive review of relevant surface mining related research was conducted to identify and substantiate suspected problem areas. Finally, a series of preliminary interviews were conducted with key personnel of the Bureau of Mines, MSHA, equipment manufacturers, and mine operations. These interviews attempted to identify meaningful problems in the operational mining environment. A phase II data collection plan, requisite data collection forms and procedures, and a plan for sampling 24 large and small metal-nonmetal, coal, and sand-gravel operations were developed.

Phase II activities consisted of a series of onsite visits to 24 operating surface mines and to their supporting processing plants and facilities. Mine site operations visited ranged in size from less than 25 to over 3,000 workers. Site management, safety, training and supervisory personnel were interviewed along with maintenance men, equipment operators, and plant operations and maintenance personnel. In addition, a human factors review of key categories of mobile surface mining equipment was conducted. Likewise, similar assessments were made in the maintenance shop, plants, and ancillary facilities on the mine properties. Finally, a series of interviews were conducted with equipment manufacturers.

Phase III activities will consist of the integration and analysis of phase II data. Specific efforts will be made to insure that the problems identified are significant and have a meaningful impact on the surface mining industry. Verification of questionable areas with industry and government

personnel will be conducted where appropriate. Finally, the problem areas will be prioritized and research recommendations leading to cost-effective solutions will be prepared and submitted.

Design and Develop Standardized Controls of Roof Bolting Machines

In underground coal mines, fall of roof is one of the three most critical hazards encountered by miners and accounts for a large percentage of all injuries and fatalities. A majority of roof fall related accidents involve roof bolting machine operators and their helpers and occur when they are attempting to bolt an unsupported roof. Research evidence suggests that lack of standardization of controls on roof bolting machines and the poor design and placement of roof bolter controls may increase the operator's exposure to roof falls as well as other hazards associated with the operation of this equipment. This project is examining the safety consequence of poor human factors design and lack of standardization of controls and is developing a set of standardized human factored controls for laboratory and in-mine testing.

The project is organized into three phases. Phase I objectives include the development of recommendations and design standards for controls. Tasks in phase I included a detailed analysis of roof bolting related accidents; analysis of roof bolter populations and their control designs; preliminary interviews with roof bolting machine operators, MSHA, and roof bolter manufacturer personnel; completion of a task analysis and assessment of operational-environmental constraints; and the development of specifications for standardized control design. Preliminary designs were then subjected to a series of evaluations and were reviewed by mine, MSHA, Bureau, and manufacturer personnel.

Phase II activities will consist of the development of final plans and specifications for proposed controls; conduct of engineering, human factors, and safety analysis of concepts; development of mockup and prototype controls; and finalization of onsite demonstration plans.

Phase III activities will consist of installation of prototype control hardware on roof bolter machines in operating coal mines and the conduct of a 6-month field evaluation. Pre- and post-evaluation data will be collected and analyzed. Refinements in the designs will be made as required.

In addition to these studies, the Bureau is, and will continue to fund, human factors R&D projects aimed at effectively and safely integrating the worker into present and future mining systems.

1970-80: A DECADE OF PROGRESS IN MINE HEALTH AND SAFETY TRAINING

by

John Adkins[1]

ABSTRACT

Specific comments on health and safety training, past, current, and future, are drawn from work sponsored by the Bureau of Mines and the President's Commission on Coal relative to current status and effectiveness of safety training as well as forecasts of future training requirements.

INTRODUCTION

The purpose of this discussion is to identify the progress that has been made in mine health and safety training over the past decade and to put into perspective the challenges that remain. Our current efforts must be sustained by the knowledge that previous efforts over the past 10 years have resulted in significant progress. This progress has resulted in an expanding inventory of materials and instructional guides, continued testing of training techniques and approaches, and other specific training products. More significantly, in the long run, it has produced a measurable increase in the awareness and acceptance, on the part of mine operators, of health and safety training as a necessary part of a total effort to reduce injury rates, improve labor-managment relations, and increase productivity.

Our general views of the progress of health and safety training are based on research and development efforts in mine training evaluations and needs assessments, hazards analyses, training materials development, and mining industry labor-management relations. Specific comments on health and safety training, past, current, and future are drawn from work done for the Bureau of Mines by Bendix[2] between 1974 and 1976, as part of a first look at the impact of training on accident rates. Data on the current status of training programs are drawn from interviews conducted by Bendix with over 500 coal miners in the past 2 years. Evaluation of the future needs and challenges of health and safety training is based on forecasts of training requirements for the next decade done for the Bureau of Mines in 1979 by John Short & Assoc., Inc.[3]

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[1]Principal investigator, Bendix Corp., Denver, Colo.

[2]Bendix Corp. Review and Evaluation of Current Training Programs Found in Various Mining Environments. BuMines OFR 76-110, 1976, 63 pp.; available from NTIS, PB 259 410.

[3]John Short & Assoc., Inc. Study to Determine the Manpower and Training Needs of the Coal Mining Industry. BuMines OFR 80-14, 1977, 142 pp.; available from NTIS, PB 80-164742.

ANALYSIS OF EARLY HEALTH AND SAFETY TRAINING EFFORTS

As John F. Kennedy once advised: "The best way to determine where we should go and how to get there is to determine where we are and how we got here."

Heeding this admonition, let us first consider early impact of the training requirements of the 1969 Coal Mine Health and Safety Act. The 1976 evaluation of mine health and safety training was designed to provide a broad description of the training programs conducted at the time by mines, vendors, State governments, and vocational schools, and to evaluate the effectiveness of these programs in reducing mining related injuries. The objective was to determine the impact of training course content, methods, facilities, media, etc., on miner attitudes, behavior, and injury rates.

The study consisted of two simultaneous but methodologically distinct tasks. Quantitative analysis of training and injury data aggregated from 300 sampled mines was one major task area. The data were obtained from the MSHA Health and Safety Analysis Center in Denver. Computerized analyses were performed. The basic analyses were scatter plots and correlational analyses using time lags and leads between various categories of training content versus injury categories.

The second task was to prepare narrative descriptions of training programs conducted by mine companies, vocational schools, equipment manufacturers, and State or Federal agencies. This effort focused on the course content, teaching approach, methods, and media used. The purpose was to determine whether specific training methods could be related to training effectiveness. Descriptions of the various approaches to training were obtained from personal visits to training sites, from letters, and from telephone calls.

Conclusions From the Statistical Analysis

For the 1970-74 period, the overall statistical relationship between training and injury reduction was weak at best. Examination of relationships among specific training courses, that is, courses aimed at specific injury causes and injury reduction from those causes, yielded more positive findings. When one examines the impact of training courses aimed at specific problem areas, for example, electrical injuries, the impact of training on injuries is more demonstrable.

Conclusions From the Analysis of Training Methods

An attempt was made to assess the effectiveness of specific training techniques, and it was found that the specific methods used were not as reliable as predictors of successful training as were more fundamental indications of management's commitment to conducting an effective health and safety program. Once a commitment was made, the mine usually introduced specific methods that depended on local needs, conditions, and capabilities.

A second characteristic of successful training was that it was based on a good analysis of the specific needs of the individual mine. Mines that identified specific problems tended to be more successful in reducing injuries than those that took a blind, shotgun approach.

A third characteristic of effective programs was that they emphasized and balanced accident prevention with disaster prevention and postaccident training. Courses like hazard recognition and accident prevention do more to reduce accidents and improve the immediate status of mining than courses in first aid or mine emergency training, etc. Periodic reinforcement of the training is also needed. Accident data showed that gradual upturns in specific accident categories could be lowered by repeating or reinforcing training. Interviews with training officers confirmed that to be effective, training must be periodically reviewed, otherwise behavior modified by training tends to wash out.

It was also found that:

Mines should remain the primary agency for training.

An information collection and distribution program is needed.

A need exists for the development of modular material packages and a structured means for disseminating information.

Emphasis should be placed on intrinsic rewards and motivation programs.

Dedicated training staffs should either provide or assist foremen in conducting on-the-job-training (OJT).

OJT should be formalized when used.

The use of training sections should be encouraged.

MSHA should help companies develop their own programs by drawing upon Bureau of Mines-MSHA material.

BENDIX SURVEY OF COAL MINERS

The Bendix Corp. has been able to take a continuing look at mining health and safety programs since the summer of 1979, 10 years after the enactment of the initial law requiring health and safety training for coal miners. This look at training is part of the current work Bendix is doing in the field of labor-management relations in the coal industry. Among questions asked of now over 500 miners at 19 mines during open-ended group discussions are questions regarding the nature, role, and effectiveness of current health and safety training programs.

Conclusions from the analysis of relevant portions of the discussion data and of the mine by mine tracking of historical data on accident rates are:

There has been a marked increase in health and safety activities.

There is an increased awareness that safety programs pay off.

There is an increased awareness of the positive association between safety and productivity.

There is an increased commitment of mine management to safety.

TRAINING NEEDS ANALYSIS

Still another look was taken at mine health and safety training in 1979. This time the purpose was to determine the training needs of the coal mining industry and to recommend a joint industry and Government approach to meeting these needs. This study, conducted under contract to the Bureau by John Short & Assoc., Inc., was directed toward examining both the supply and demand components of the training system. This was accomplished through an extensive literature search, 42 site visits to mines, schools, manufacturers, and consultants, discussions with 108 training providers, and an assessment of 47 company reporting units covering 73 mines employing 16,000 miners. The investigators then assessed the current extent and future projections of training nationwide and by region.

Six providers of training were identified: Mine companies, schools, State and Federal agencies, equipment manufacturers, consultants, trade associations and unions. The study described how each of these entities provides training and what type is provided by each.

Conclusions of the Training Needs Analysis

The principal finding of the study is that employment growth will moderate indicating that the coal industry, while forecast to experience high production growth in the next 15 years, will not be in a crisis situation in dealing with the training of large numbers of new employees. In fact, the decade of the seventies has demonstrated a significant growth in the attention given to all aspects of mine training by coal producers as well as by external suppliers (vocational schools, community colleges, trade associates, consultants, manufacturers, labor organizations, and Federal and State agencies). Problems in the supply of training may appear on a local level, but the impact of these can be minimized through efficient and timely use of the resources of existing organizations. However, the major issue requiring continued and additional emphasis is whether the training is efficient and effective. Additional findings include:

Coal companies, using internal programs, will remain the major source of training.

External providers are often unresponsive to market conditions and have, in some regions, created an oversupply of "trained people."

Small coal companies rely on external or cooperative sources focused onsite to both minimize cost and maximize effectiveness.

There is a lack of communication and coordination among the training providers, particularly with regard to development efforts.

The quality of training is very uneven--more needs to be known about effective training techniques.

There are few perceived positive incentives in the industry to provide quality training rather than training for compliance only.

Recommendations

Principal recommendations include:

Creation of a mining extension service patterned, in function, after the Agricultural Extension Service. Such a system, applied to mining, should provide the needed interindustry and intraindustry communication it now lacks while serving as a feedback system that focuses research and development efforts on local problems.

Development of regional resource centers. These centers would provide a focus for information exchange, a point of contact for local operators to obtain assistance and information for specific training problems, regional coordination of mine vocational and educational resources for external training providers, and local research activities on identifying and improving training effectiveness.

Tax incentives for training. This would provide a positive incentive for the development of training facilities and purchase of equipment by individual mining companies.

Establishment of a Federal interagency committee. This committee would coordinate resources and efforts of the various Federal agencies involved in mine training and related activities.

PROGRESS IN THE LAST 10 YEARS OF COAL MINE SAFETY TRAINING

As indicated in table 1 activity in the field of safety and skills training increased dramatically through the first half of the 1970's. Aside from the training and certification of thousands of miners, several specific accomplishments can be noted. Some old problems have yet to be solved and some new needs and opportunities now exist, partially as a result of the progress that has been made.

TABLE 1. - Incidents of health and safety training for all mining reported from 1971 to 1979

Year	Total mining, including coal	Coal mining only
1971.............	122,000	100,000
1972.............	258,000	187,000
1973.............	376,000	288,500
1974.............	569,000	430,500
1975.............	677,000	522,000
1976.............	595,000	443,000
1977.............	434,000	299,000
1978.............	354,000	242,000
1979.............	241,000	162,000

Basically, over the past 10 years, the mining community has invested heavily in realizing the social and economic benefits of health and safety training. As part of that investment, mining research has contributed in this growing acceptance of the value of health and safety training, has provided basic guideline materials for safety and skills training, has researched the application of various training methods, and has assisted the industry in reaching a point where we all can begin to explore more effective, higher quality programs.

Course Content and Scheduling

Research has shown that health and safety programs pay off in reduced injury rates and has provided direction for more effective training.

Annual retraining, for example, is a direct outgrowth of evidence that the effectiveness of safety training diminishes with time and that reinforcement of safe behavior via a refresher program can help to reduce accidents. Course content and emphasis have also been improved by research on the usefulness of various courses.

Current work on accident investigation techniques is expected to provide more specific techniques and tools for managing and evaluating training investments.

Course Guidelines

In direct response to research recommendations, the Bureau of Mines has sponsored the development of course outlines and subject matter and has worked with MSHA in making this material available to the coal industry in a series of training modules. These guides help the individual instructor to define general course goals that comply with required training and to present specific course content.

Additional guideline materials have also been prepared supplementing and formalizing industry-sponsored training for developing occupational skills.

Delivery Systems

Research has been directed toward investigating the potential of innovative delivery systems; that is, methods of getting the training accomplished in the field. These would include work on self-paced individualized material, criterion referenced instruction, computer-based training, equipment training devices, and preliminary research in developing a system for providing training during the mantrips.

Organizational Variables

Completed studies and current demonstrations are providing specific guidelines in assisting mining companies in their efforts to improve the effectiveness of their safety program and general mine management through the application of organizational development techniques.

Mining companies are becoming increasingly capable of making the American miner not only the best trained in the history of the industry, but also among the most highly skilled blue collar worker in all of U.S. industry.

WHAT REMAINS TO BE DONE

The primary need now is to enhance the quality of the training being provided. As noted earlier, this quality depends not so much on specific methods or media, as on corporate commitment to the training program. There are, however, specific directions that should be taken to improve it. The provisions for assisting coal operations, recommended by the John Short study, is an innovative and promising suggestion. There are several areas in which the service could work.

Data-Based Courses

Local mine company safety analysts and training officers need to perform rudimentary analyses of mine accident data and to translate the findings into course content. Trainers need to learn to collect, analyze, and present accident data so that the training program can focus on the real training needs of the mine and so that those needs can be effectively communicated to management.

Worker Participation

One of the characteristics of effective, high-quality training seems to be the participation of the work force in the development of the training program. Experimental programs and guidelines need to be developed so that specific means for encouraging such participation could be distributed to the industry.

Feedback and Testing

Quality training is characterized by mechanisms for providing feedback to both the instructor and the trainee on learning and performance. Too often material is presented but no means are provided for either the instructors or the students to find out how they are doing. This is both inefficient and frustrating. Instructors need to know whether the student has acquired both content and skills and how their teaching can be improved. Trainees need to

be given feedback on how well they are doing. They need to be recognized and rewarded for progress made. Lack of reward and recognition may account for a large measure of the persistent attitude of miners that they have not received any formal training, even when records show that they have.

Professional Trainers

Although there are more people from training and education backgrounds managing mine company training programs now than a few years ago, the tendency to assign other disciplines to that role rather than to hire a professional trainer persists. The quality of training is now at a point where improvements will be most readily made by people who understand and can apply the gamut of training and education principles and technology.

Effective Use of On-the-Job Training

Despite the expansion of formal health and safety training programs, the primary source of skill training remains on-the-job training (OJT). Rather than eliminate this traditional source of learning, methods need to be developed for making OJT much more effective. The quality of OJT would be enhanced by formalizing procedures and developing tools and aids specifically designed to assist the instructor and the student in the training process. OJT needs to provide some recognition and feedback to the student. Too often the trainees are shown the job and how to perform the tasks but are not told whether they have or have not performed safely.

Improved Accident Investigation

One of the chronic problems is the inability of mine health and safety officers to perform professional accident investigations. Too often the only purpose of an investigation is to fill out an accident report form. Largely due to a lack of useful procedures and training in accident investigation techniques, health and safety officers often do not generate the type of accident data that could be used to guide their own health and safety training efforts. Safety and training officers need to aggressively pursue the use of computer-based data systems to track mine accident patterns as well as the training progress of individual trainees.

CONCLUSIONS

As the number of agencies and the variety of people working in the area of coal mine health and safety and related field expands, and as the work in the area becomes more diversified and sophisticated, a commensurate need will develop to open more effective lines of communication and cooperation among industry, government, research and development firms, and academic institutions. Greater participation of the mining industry in the professional safety and training community would enhance this communication. Seminars such as this one are another basic need. For each of us, however, the challenge is to identify our own talent, to seek our most appropriate role, to play that role with vigor and honesty, and to make the incremental contribution set before us by each project and program of which we are a part. For that is how we have come to be where we are, and that is how we shall ultimately reach our mutual goal of making our miners the technically skilled, safe, and productive labor force needed if we are to realize the benefits of our Nation's vast mineral wealth.

ACCIDENT INVESTIGATION: IMPLICATIONS FOR SAFETY RESOURCE ALLOCATION

by

James M. Peay[1] and Louis Schaffer[2]

ABSTRACT

The Bureau of Mines has a continuing interest in promoting safer working conditions for this Nation's miners. As evidenced by the other papers included in this publication, the Bureau has provided significant assistance in areas of miner training. This paper is related to another Bureau of Mines program entitled "Research Study To Determine the Applicability of New Methodologies in Mine Accident Investigations" (contract J0308008). This program is primarily oriented toward assisting the Mine Safety and Health Administration in the development and implementation of improvements in the methodology used to investigate mine accidents. This program may also result in the development of an accident investigation methodology that will be of direct usefulness to mining companies. The Bureau of Mines is considering the possibility of holding workshops to train mine personnel in the use of this new methodology. Another aspect of this methodology that will be of interest to the mine safety director is the potential for determining the true costs of accidents.

This paper illustrates differences in various approaches taken in investigating accidents and the resulting differences in action taken to reduce future occurrences.

INTRODUCTION

Some lines written long ago by Disraeli express the underlying theme of this paper:

> "Man is not the creature of circumstances,
> circumstances are the creatures of men."

The conditions or circumstances that affect the risk of accidents are created by human beings. We must reject the notion that "acts of God" have a significant role. As Frank A. Haight observed in a recent paper,[3] the act of God interpretation of accidents "is by now nothing more than a piece of legal lingo for an insurance exclusion." Haight also noted that if everyone believed a "deistic force" selected persons injured in accidents for personalized attention, "any effort to alter the situation would surely be perceived as sacrilege, and sacrilege is one of the few arguments not usually marshalled against safety programs."

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[2]Project manager, Woodward Assoc., Inc., San Diego, Calif.

[3]Haight, F. A. What Causes Accidents--A Semantic Analysis. Pres. at the 1980 SAE Ann. Cong., Detroit, Mich.; SAE Special Publication SP-80/461, pp. 51-54.

The term "accident," as used here, refers to any unintended event; that is, an event that indicates a system control failure. An accident always results in cost (loss) in one or more ways, but not necessarily in injury to persons. (There can be an accident without an occupational injury, but, with some few exceptions, there cannot be an injury without an accident.)

The term "cause" is usually avoided. There are many substantial grounds to avoid this term when speaking of accidents. Some are semantic, some are legal, and some are related to the confusion that the notion of cause frequently introduces into the development of accident countermeasures. From our point of view, the last set of reasons is the most important. The accident investigation methodology that has been developed recently by the Bureau of Mines, and is being evaluated in the field by the Mine Safety and Health Administration, does not speak of cause. This is primarily because use of the term tends to focus the investigative process and subsequent management actions on only one, or a few, of the acts, conditions, or circumstances that precipitated an accident. Consequently, many "contributing factors," and the related countermeasures that are often effective and inexpensive, do not receive consideration.

WHY INVESTIGATE AN ACCIDENT?

There are many reasons to investigate an accident. Ludwig Benner, Jr., of the National Transportation Safety Board, has reported on queries to more than 200 investigators that revealed many had difficulty articulating such reasons. Benner lists 44 reasons that had been reported over a period of several years and noted that only once was "understanding the accident phenomenon" given as a reason for investigation.[4] Understanding accident phenomena certainly should be a fundamental reason for accident investigations because it is only after such an understanding has been attained that the development of countermeasures and the implementation of policies and procedures can be addressed.

However, there are several other reasons why accidents should be investigated. An important but frequently overlooked reason is related to the benefits to be gained from involving workers (safety committee members and others) in the investigative process. Several mining companies have found worker participation (sometimes leadership) to be very desirable. A NIOSH research report entitled "Safety Program Practices in Record-Holding Plants"[5] notes that plants with outstanding safety records in five industries followed the policy of conducting investigations with "worker-management teams" composed of safety staff members and "plant management, medical personnel, worker representative(s), involved employee(s), and supervisor(s) of involved employee(s)." Investigations included "known near-misses accidents, whether there was property damage or not."

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[4]Benner, L., Jr. Accident Investigations--A Case for New Perceptions and Methodologies. Pres. at the 1980 SAE Ann. Cong., Feb. 28, 1980, Detroit, Mich.; SAE Special Publication SP-80/461, pp. 27-44.

[5]Cleveland, R., H. H. Cohen, M. J. Smith, and A. Cohen. Safety Program Practices in Record-Holding Plants. DHEW (NIOSH) Publication No. 79-136, March 1979, 144 pp.

In order that accident investigation results may have maximum value in management decision processes, the investigative procedure must be both thorough and consistent. Consistency is essential for successful aggregate accident data analyses. Thoroughness is necessary to avoid missing significant factors in both individual and aggregate analysis, although these "factors" need not be "proven" by the investigator to have relevance to the specific accident under investigation. Indeed, relevance is sometimes apparent only after aggregate analyses have been completed.

AN ACCIDENT INVESTIGATION

It would be convenient if one could cite a "typical accident" to illustrate certain points. Unfortunately any mining accident that one might select could be considered "typical" of only a small class of accidents or "typical" only in the sense that many actions, conditions, or circumstances contributed to its occurrence. The accident discussed here is considered typical only in that sense.

Investigation by the Mine Safety Officer

The following information elements resulted from a "preliminary investigation" done by the mine safety officer, using no particular methodology except seeking "answers to questions my management will probably ask":

An experienced equipment operator, "John Doe," received minor injuries to his head when the equipment he was operating overturned (90° roll) at the West waste dump. Doe had been employed there for about 8 years.

The equipment was one of the rubber-tired dozers normally used for cleanup around the shovels and other pit work, but was being used on this day to do some area maintenance and berm construction at the dump.

The accident occurred about an hour after the start of the day shift. There were no witnesses. Doe got out of the machine and walked to the haul road. He was bleeding badly from a head wound, according to the electrical foreman who picked him up and took him to the first-aid station. Doe estimates that he was picked up about half an hour after the accident. The foreman called the safety officer and mine manager on his radio enroute to the aid station. The ambulance crew arrived at the aid station at nearly the same time as Doe. The crew administered first aid and took Doe to the hospital. The attending physician at the emergency room treated him and released him. The doctor said that he was not seriously injured. He had a 2-inch laceration on the front of his head near the hairline, abrasions on his left cheek, and foreign material in his right eye. The doctor told the ambulance crew that Doe could return to work in "a couple of days."

The dozer was not seriously damaged. It was righted and pulled onto flat ground with a crawler tractor. The maintenance foreman drove it to the shop for checking.

In the judgment of the safety officer, the accident resulted from Doe's failure to use care when working near the edge of the dump area.

The safety officer's report was given orally to the mine manager, the operations manager, the shift foreman, and the personnel manager. According to the safety officer, everyone present agreed that "the cause was the operator error" and that "corrective action would be to discuss the accident at a 'lunch paid' safety meeting and to have training instructors emphasize the need for care while working machines near edges."

The company has an "accident investigation report" that is usually completed by a foreman or by the safety officer. The report form was created "to comply with Part 50" (30 CFR 50.11). The report must include:

1. The date and hour of occurrence.

2. The date the investigation began.

3. The names of individuals participating in the investigation.

4. A description of the site.

5. An explanation of the accident or injury, including a description of any equipment involved and relevant events before and after the occurrence, and any explanation of the cause of the injury, the cause of any accident, or cause of any other event that caused an injury.

6. The name, occupation, and experience of any miner involved.

7. A sketch, where pertinent, and including dimensions, depicting the occurrence.

8. A description of steps taken to prevent a similar occurrence in the future.

9. Identification of any MSHA Report Forms 7000-1 submitted.

The safety officer believed that his "preliminary investigation" provided not only all of the information needed for the company and MSHA reports, but also all of the information of any value to management safety policymaking.

Investigation by the Mine Manager

The mine manager had a different view. Although he said little about the safety officer's report, he was concerned that he had too little information about accidents. In labor negotiations, safety practices and accident investigations had been discussed frequently. The mine manager had "a gut feeling" that there were "too many accidents and too much loss." He asked one of his junior staff members and the chairman of the local union safety committee to "make a thorough, impartial investigation." These two people took a full day for the assigned task. Their report to the mine manager included the following "new" information:

> It was raining heavily at the time of the accident--the first rain in more than 3 months at the mine. The haul roads and dump areas were slippery. There were several small mud slides.

The rubber-tired dozer was used for the job at the West dump because Doe chose to use it. The crawler dozer at the dump did not have an enclosed cab. Doe wanted to use the rubber-tired dozer because it had a cab in which he could be dry and comfortable while working. The dozer was available for use because one of the shovels was not operating. Doe told his foreman that he "would like" to use the machine and "stay dry" because he had "a bad cold." The foreman said nothing, he merely nodded. Doe understood this to mean approval of his request. The foreman denies that it was a request, or that he gave approval.

After about 45 minutes of work at the dump under what Doe describes as "very poor conditions of footing and visibility," he was pushing waste over the edge and "the bank gave way." The machine went forward down the bank "at an angle of about 45° for nearly two machine lengths." Doe applied brakes the "instant the earth gave way," but could not stop forward movement immediately. When the machine stopped, he "thought about the problem for a minute" and decided to try to move the dozer further forward (about 20 feet) to undisturbed ground and then get back on top of the dump at a place where the bank was less steep. He said that he decided on this action because he "didn't want to get out in the rain" and because "if they had to come and pull the thing out, all the other guys would razz me and it might screw up my incentive pay somehow." While attempting to move the dozer forward, "it was steering hard in the mud and the rear wheels slipped downgrade to the right so that it was sideways on the slope and it just laid over on its side."

Doe's head injury was received when his head hit the top of the cab frame or rollover protective structure. The abrasions on his cheek were, he thought, the result of slipping and hitting his face on the floor of the cab while he was trying to get out. He was not wearing a hard hat. The seat safety belt in the dozer was in good condition, but Doe did not use it. There were loose articles in the cab (lunch pail, two wooden blocks, and "a lot of dirt and small rocks"). Doe said that dirt got in his eyes when the machine rolled and that he didn't get it out until he reached the hospital. "The tough part was getting out, climbing the slope, and getting to the road half-blinded." Doe was not wearing safety glasses. The total roll was approximately 60°. The machine came to rest on its right side parallel to the edge and about 35 feet down a 50° to 60° slope.

When the ambulance crew leader called Mrs. Doe from the hospital, at Doe's request, her first statement was that "he shouldn't have gone to work today--he's been sick all week." Doe had what he described as "a severe cold." He became ill while on vacation (the 2 weeks before the accident; the day of the accident was his first day back to work). He had not received medical attention, but was taking a non-prescription medication. The label warns that the drug may produce "dizziness, disturbed coordination, restlessness, nervousness," and other side effects. Doe had been taking 1-1/2 times the recommended dosage during the previous 3 days.

Doe was hired 7 years, 8 months and 4 days prior to the accident. He had no "MSHA reportable" (lost-time) accidents in the past 5 years for which records were available. The company had no records on "minor accidents" that involve only first-aid injury treatment or equipment damage. Doe said that he has had "only a couple of cuts and bruises" since his employment and had "only missed about 10 days of work in 8 years--all on account of colds and like that." The personnel records support his statement. They show 12 days of absence, all on sick leave. Doe was hired as an "experienced mobile equipment operator" with 10 years of prior experience in that occupation and in mining. He said that he never had any training on any equipment, but that he "learned by doing." He had operated here, and in his previous jobs, trucks, front-end loaders, crawler dozers, scrapers, and graders. For the past 5 years he had operated crawler dozers and graders primarily, with occasional periods of a few days as a "relief driver" on ore trucks. He is a "training instructor" for "checking out" new workers on crawler dozers, scrapers, and graders. He could not recall exactly when he had previously operated a rubber-tired dozer, but stated that he had "not been in one for a couple of years."

The dozer involved had the following maintenance deficiencies prior to the accident, according to maintenance records, end-of-shift condition reports, and the statement of the man who last operated it:

Windshield cracked in two places.

Brakes weak.

Radio broken.

Wiper blade no good.

Tires due for replacement.

There was no apparent damage to the dozer in the accident except that the right window was broken out.

Doe had no contact with his supervisor except at the beginning of the shift when he "requested" (as previously noted) to use the rubber-tired dozer. No one else came to the West dump area while he was working. After the accident, Doe went to a crawler dozer parked at the dump (the one usually used for the job he was doing). It had no radio. Doe considered using it to get to the first-aid station but he couldn't get it started "in about three tries." The machine started normally the following day.

Although not asked to identify cause by the mine manager, the two investigators declared "the cause of the accident was operator error" and that Doe "violated paragraph 55.9-24 of the MSHA regulations by not maintaining full control of his equipment while it was in motion." A "contributing cause" was, they said, "improper maintenance which violated paragraph 55.9-2 of the MSHA regulations in that equipment defects which affect safety were not corrected before the equipment was used."

Postaccident Review

The mine manager spoke briefly to Doe when he returned to work 2 days after the accident. Doe said: "It was all my fault. I was trying too hard to do my job right. I should have got out of the dozer and gone for help when it went down the bank, but I thought I could get it working again without wasting other guys' time."

The mine manager computed the cost of the accident, concluding that it was at least $1,260, plus $344 for the investigation he had requested, though he felt that the men who did the investigation "learned a lot" and that the $344 was "a good training investment." His view of the accident was that it was not "caused" by the operator but by "several management breakdowns." (However, the Form 7000-1 submitted to MSHA shows the accident to be "caused by operator error" and the corrective action is noted as "additional training of operators who work while rollovers are possible.")

RESULTS OF THE INVESTIGATION

There is a happy ending to all this. The mine manager required that all accidents that produced injury or property damage be investigated immediately. He created a new investigation report and instructed investigators to "identify any condition or event that may have a bearing" on the accident. Investigations were done by one management person and one union safety committee member. The management representation was "rotated" among all line and staff management people, except clerical, at or above the shift foreman level. The mine manager "budgeted time" so that he devoted at least 4 hours a week to safety matters. He personally talked to every person involved in an accident, and to that person's supervisor, at the accident site. He arranged a joint management-union review of the incentive program with particular emphasis on health and safety implications. He stressed safety responsibilities at all management meetings, pointing out that "MSHA rules are mostly countermeasures developed from previous accidents" and that "to ignore them is to ignore lessons learned by others the hard way." He frequently attended safety meetings and gave what he called "very short summaries of what was being done to improve safety." He asked for criticisms and suggestions, which he wrote down and later reported on in terms of actions taken. He conducted a review of all accident information every quarter with the safety officer (who now reported directly to him) for the purpose of deciding what policy and work practice changes should be made and how safety resources should be increased, decreased, or reallocated.

Approximately 8 months after Doe's accident, the mine manager and his key staff members reviewed the safety program with corporate officials. The cost of accident investigation was, by this time, averaging less than $200. The quarterly accident rate was shown to have decreased substantially (by about 40 percent, according to estimates by the mine staff). The "savings" on "loss reductions" were estimated to be approximately $10,000 a month net; that is, after the cost of investigations and other "new safety practices" was deducted. Actually, the cost of new safety practices was very small, according to the manager. What had been done was "primarily getting management people to do

what they should have been doing, and were paid to do, all along." The allocation of safety resources was "mostly a matter of getting people at all levels to be more safety conscious." He said he believed, but "could not yet completely prove with numbers," that "productivity, job satisfaction, and labor relations" had improved. He was able to cite reductions in absentee and grievance rates, but could not give credit to the safety program alone for these improvements.

What the manager had done was to create a new management atmosphere in which safety concern was manifested, in word and deed, by everyone in management and by a majority of the employees. And that, of course, is the most effective single countermeasure of all against accidents. He had also allocated his resources in more effective ways to manage safety. He could do this because he had available the necessary information, reports, and personal observations on which to base sound management decisions.

CUSTOMIZING MINER TRAINING

by

Thomas L. Savage[1]

ABSTRACT

This paper discusses a development effort in preparing a specific set of procedures whereby miner trainers can substantively improve the instructional quality and effectiveness of training conducted in compliance with 30 CFR, Part 48. As such, the discussion centers around the development of a tailoring manual (Bureau of Mines contract J0188069) designed specifically to provide the miner trainer with an efficient procedure for adapting existing training materials to the specific health and safety needs of the workforce.

INTRODUCTION

One challenge facing miner trainers is in adapting or supplementing training materials to create a thorough, effective training program. Even the best commercial training program available will not address all the particular problems and situations faced in an individual mine.

Many training programs are currently offered to meet the requirements established in 30 CFR, Part 48. The majority of these programs are general in nature, and are written for a specific topic rather than a specific mine. The material is usually developed by topic (ventilation, electrical hazards) or type of training involved (training of inexperienced miners, annual refresher training).

Tailoring offers the trainer the opportunity to make the materials directly relevant to the specific mine environment. Miners must be convinced that the material covered in the training will benefit their own personal health and safety. Without tailoring, trainees often lose interest and become bored with off-the-shelf materials. As would be expected, these conclusions are supported by training evaluations[2] which have indicated that compliance training is not an effective means for reducing injuries.

This paper discusses the development of a formalized set of procedures that miner trainers can use to improve the quality and effectiveness of training conducted in compliance with New Miner and Refresher Training elements of Part 48. The product was a tailoring manual designed to provide the trainer with an efficient procedure for adapting existing training materials to be more applicable to the trainee's true job environment and site-specific health and safety needs.

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[1]Associate director, Mining Extension Service, West Virginia University, Morgantown, W. Va.

[2]Bendix Corp. Review and Evaluation of Current Training Programs Found in Various Mining Environments. BuMines OFR 76-10, 1976, 63 pp.; available from NTIS, PB 259 410.

DEVELOPING THE TAILORING GUIDE

It was determined that the best approach in developing the manual would be to actually tailor the Part 48 materials for several mines, and from the experience gained, prepare a manual listing the step-by-step process necessary to adapt training material to the specific needs of a particular mine.

The project staff worked with three sites, two small Kentucky mines and a larger Maryland mine. The team directed their initial efforts in:

1. Observing actual mining operations.

2. Obtaining a list of machinery in use.

3. Determining mining methods.

4. Observing hazards (roof, water, etc.).

5. Observing type of roof supports.

6. Obtaining emergency evacuation, ventilation, and roof control plans.

7. Listing safety problems.

Following onsite data collection, the project team contacted the safety director or general mine foreman to clarify any questions that still existed. Draft materials were prepared and field tested at the participating sites. Following documentation of the tailoring procedure, recommendations and suggestions for the manual were made by various company trainers at other mines and were adopted where appropriate.

TAILORING MANUAL

The final product is a manual of approximately 50 pages. In addition to a step-by-step example in tailoring the Part 48 material, the manual contains six sections:

1. Introduction.

2. Why Tailor? The philosophy of tailoring and why it is necessary.

3. Preparing for Tailoring. Gathering information, familiarization with the training program, and examples of charts and forms used for gathering and cataloging information.

4. The Tailoring Process. The procedure for actual tailoring and writing of the modules, including pictorial examples of how to modify materials, changing visuals and tests, etc. Also included is a reference guide explaining the components (notes, lectures, self-checks, etc.), of the Part 48 instructional materials, as published by MSHA.

5. Keeping Up to Date. Suggested ways to maintain the currency of tailored modules and keep track of changes.

6. Appendices. A listing of the Part 48 training modules, suggested presentation methods, sources of additional information, methods for constructing a tailoring questionnaire, and sample checklists for collecting information.

CONCLUSIONS

Often times, the cost of customizing existing materials is much less than in developing an in-house program. It is estimated that a person familiar with the operation could prepare the tailored Part 48 training materials in approximately 2 weeks. Once a training program is tailored, it is relatively easy to upgrade on a periodic basis to guarantee continued relevance.

Customized materials are not the entire solution to more effective safety training. In many cases, however, they are an indication that the organization is seeking to actively address health and safety issues.

IMPROVING THE EFFECTIVENESS OF CLASSROOM INSTRUCTION

by

Jeanne T. Bernard[1] and Michael Digman[2]

ABSTRACT

This paper is concerned with a limited aspect of miner training; that is, improving the effectiveness of classroom instruction. As such, the study methodology included the monitoring of a wide variety of classroom sessions conducted for new miner and annual refresher training. Field data collection involved audiotaping of classroom sessions, pretesting and posttesting of trainees, and interviews with students and instructors.

These efforts provided information as to the identification and documentation of instructional strategies, broad guidelines for the use and limitations of various classroom evaluation techniques, and suggestions for improvements in the design and implementation of classroom training. Conclusions drawn provide evidence that further research efforts are needed, particularly in the area of designing innovative evaluation techniques for assessing trainee performance as well as the design of better observation research techniques for conducting aggregate evaluations of health and safety training.

INTRODUCTION

Industry-wide efforts to improve the quality of formalized training have taken many avenues, including simulated work environments, extensive use of classroom facilities, structured on-the-job training, and performance-based supervision. If training is to fulfill its potential as a principal contributor to improved work performance, continuous improvements in the quality of training must be investigated.

The attention given to safety and skills training by members of the mining community has likewise increased greatly over the preceding decade. A sizable percentage of the increased attention can be attributed to training mandates as outlined in the 1977 Federal Mine Safety and Health Amendments Act. These mandates were subsequently promulgated under 30 CFR, Part 48--Health and Safety Training and Retraining of Miners.

Much of the health and safety training provided to new hires and experienced miners (refresher training) is conducted in the classroom. Many individuals and organizations have independently pursued improvements in effecting

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better use of classroom training. Current estimates[3] for 1981 indicate that approximately 3.7 million hours of health and safety training will be provided to our mining work force by conventional classroom training.

Since it is expected that this already sizable investment will experience significant growth through this decade as the demand for minerals and energy increases, any improvements in more effectively utilizing this resource can result in significant benefits to the miner, industry, and society.

STUDY DESIGN AND METHODOLOGY

This observational study of new miner and refresher training (Bureau of Mines contract J0188069) involved three facets:

1. Monitoring of classroom training including audiotaping instruction and class participation and interviewing trainers and trainees.

2. Administering pretests and posttests in order to assess the extent to which classroom objectives had been achieved.

3. Identification and documentation of apparently effective instructional strategies and evaluation techniques.

Participation was voluntary on the part of the providers of the training. Approximately 30 different providers, including coal companies, schools, colleges and universities, and private training companies were contacted. Of these contacts, 15 trainers agreed to participate. Data collected reflect the efforts of seven different trainers at 14 site locations in Kentucky, Maryland, Pennsylvania, and West Virginia. The findings and observations of this study are categorized according to new miner and annual refresher training.

Since it was not possible in this field experiment to exercise rigid control over study parameters, the findings and observations serve solely as an estimation of the trainee's performance. It is recognized that other factors (for example, trainee's previous experience) contributed to the trainee's performance.

In addition, the instructor at each site for each type of training developed his own training agenda. There was no control over the course design or method of delivery. These factors and others contributed to the trainee's performance and are considered in the interpretation of the results.

Training materials used by the trainers varied significantly although topics and objectives were rather consistent for new hire and retraining classes. Training materials and methods were often based on or supplemented by material distributed by MSHA, which consisted of modules for each prescribed topic outlined in 30 CFR, Part 48.

In order to obtain some estimates of the effectiveness of the classroom training, two samples of test items (used as a measure of trainee performance)

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[3]John Short & Assoc., Inc. Study To Determine the Manpower and Training Needs of the Coal Mining Industry. BuMines OFR 80-14, 1977, 142 pp.; available from NTIS, PB 80-164742.

were randomly selected from an item pool previously developed for use with the MSHA modules, each module being equally weighed. Additional items were developed for those topics that did not have sufficient test items.

The pretest was administered at the beginning of the training program and the posttest was given at the completion of the program. The difference between the two scores can be said to represent a change in the individual's performance that can be attributed to the training. Some participants were also administered progress checks during the course of the training. Each progress check relates to a specific objective covered in a module. Performance on the progress check served as a measure of the level of mastery of the objectives tested.

Since the instructor had total command over course design and delivery, it was essential to monitor the instructor's presentation. Audiotaping was used to document the various training techniques. These tapes were coded and analyzed on the basis of time spent in each subject area and on the method of presentation and class participation.

Demographic information was obtained on each miner through short surveys. These surveys also gathered information on important aspects of the training program that could not be measured through the pretests, posttests, progress checks, or audiotaping. These included trainee reaction to class participation and suggestions for revision and improvements to the training program. Similar surveys were administered to the trainers to obtain information on their course design, instructional strategy and personal reactions to the study. Figure 1 represents the evaluation strategy used in the field study.

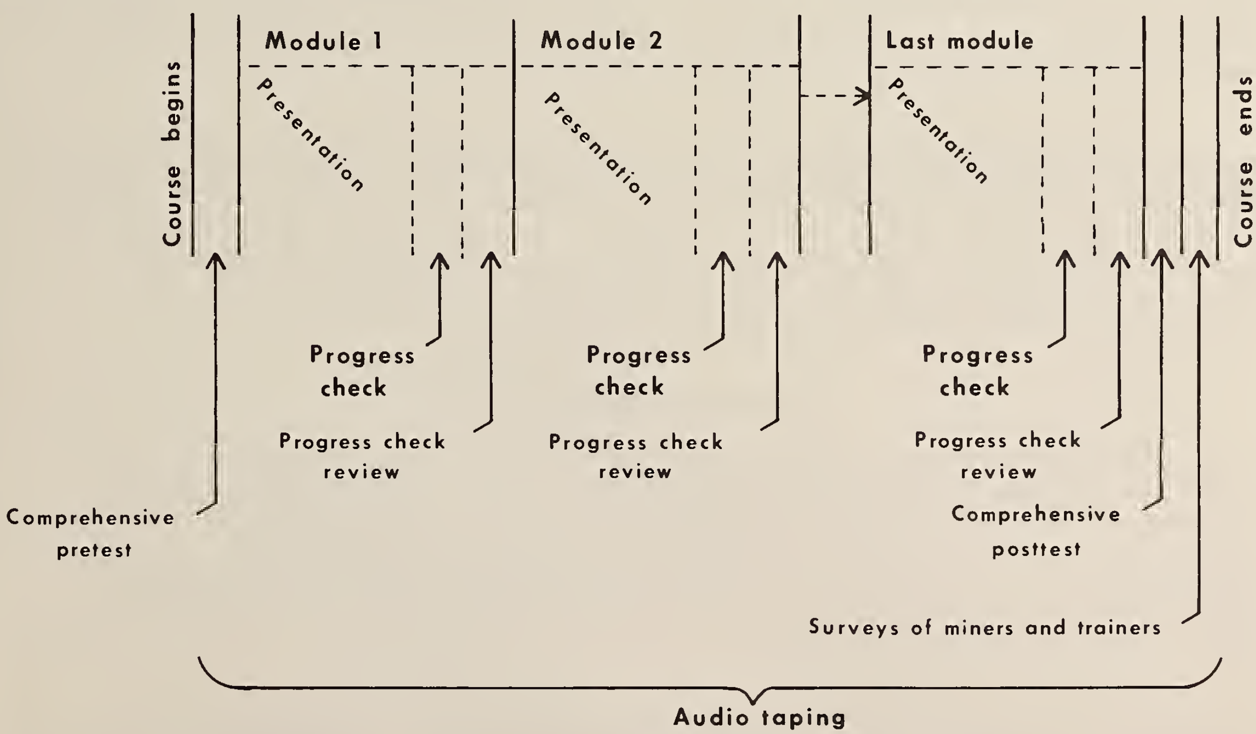

FIGURE 1. - Structure of a health and safety training course.

FINDINGS AND OBSERVATIONS

This study provided a base for establishing more intensive efforts relative to the design of innovative measurement techniques for evaluating trainee performance; greater emphasis on improving trainer skills and dealing with the issue of trainee motivation and time limitations, particularly for the annual retraining.

Design of Better Measurement Techniques

In terms of the test scores alone, it appears that many training objectives are being achieved, as significant gains were evidenced. The average test score for the new miner training was 50 percent correct for the pretest and 79 percent correct for the posttest. For the annual refresher training, the average pretest score was 59 percent correct, and the average posttest score was 71 percent correct. The smaller gains for the annual refresher training were compromised in some cases by lack of time and haphazard responding. It should be pointed out that we are not advocating extensive use of written pretests and posttests. These were used for the purposes of this study to serve as criterion variables.

Most of the participating trainers were not using extensive pretests and posttests for the obvious reason that it is a time-consuming process indicating that conventional measurement techniques are not entirely appropriate. An additional factor is that knowledge and performance are, in many training elements, entirely different issues. Some trainers were utilizing self-checks as a method for determining whether trainees had mastered important aspects of the material as well as assisting the trainee in prioritizing that content material essential for his health and safety.

Additional work needs to be done in defining and developing efficient and innovative methods for assessing trainee performance. These measurement and evaluation techniques would serve to assist the trainer in prioritizing content by specifying precise and measurable training objectives; tailoring the content and method of presentation based upon an assessment of what the trainees already know and do well; and evaluating the trainers efforts to improve the instructional arrangement over time.

Improving Trainer Skills

Improving trainer skills will be a key issue in upgrading the quality of miner training. The observational data of this study indicated that instructor credibility and presentation style varied considerably. Data also supported the belief that miner training is highly trainer intensive. The effectiveness of a program can rest almost solely on the trainer himself, since he is responsible for encouraging feedback, evaluating trainee performance, and motivating the miner.

In addition to instructor turnover, it is estimated that for every increase of 1-million hours of classroom instruction, an additional 1,200 to 1,500 new full-time trainers will be needed. How will these new trainers be selected and how will they be trained for their role? Plans are underway to

conduct a pilot workshop designed to address the issue of strengthening trainer skills in the general areas of customizing materials, encouraging participation, arranging for feedback, assessing trainee performance, and arranging or scheduling class sessions. More intensive efforts are certainly needed.

CONCLUSIONS

Classroom training is a complex issue. Even the question "When is formal classroom training necessary?" is not easy to answer. Without good methods of designing and assessing training, no trainer can hope to improve utilization of that resource except through trial and error.

A great deal of work still lies ahead in determining more effective means for training the mining workforce. The results of this study do not give procedures that guarantee effective training. They do, however, define those areas that warrant additional investigation. The mining industry, with its federally mandated training, provides the industrial trainer and the researcher with fertile ground for developing and customizing better instructional and evaluation methods. The technology for superior training exists; the challenge is to apply, document, and evaluate.

FORMALIZING OCCUPATIONAL TRAINING

by

Jeanne T. Bernard[1] and William J. Wiehagen[2]

ABSTRACT

Recognizing that well trained workers do a better job and contribute significantly to increased safety and production, many mining companies are interested in upgrading their occupational training programs. This paper discusses continuing efforts of mining research in developing training materials, instructional guides, and evaluation procedures to assist the mining community in formalizing occupation training. The materials developed are viewed as only one process to meet performance objectives through off-job-site training (OJST) and on-the-job training (OJT).

INTRODUCTION

Not many years ago, the great majority of skills training in the mining industry relied "heavily upon either a father to son 'pass through' of knowledge or on-the-job learning process by doing."[3] This expression implies that the process of learning and practice (training) did not necessarily precede the assignment but began with the new worker taking his place in production process. This practice was found not to be unique to the mining industry. A recent literature review of industrial on-the-job training (Bureau of Mines contract H0308028) points out that most OJT is unstructured and deficient in a formalized training procedure. Department of Labor sponsored studies of on-the-job training support this finding. These studies consistently indicate that most firms report the use of OJT. However, the majority of the firms (up to 96 percent, as stated in one study) operated an informal or unstructured program.

Structured occupational training has proven effective in accelerating skills development and is a necessity for many mining occupations. Major progress has been made in developing more formalized training processes. The number of training sections, company-sponsored training schools, and specialized skills training (such as welding) offered through vocational education, are growing. Instructional materials have also been prepared and made available through trade associations. Manufacturers have developed training equipment, training aids, and other instructional materials. Many large companies are currently using their own comprehensive training programs.

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[3]Aerospace Corp. An Overview of Skills Training in the Underground Coal Mining Industry, Dept. of Energy Contract ET-78-C-03-2183, Report No. SAN-2183-4, August 1978, 127 pp.

The Bureau of Mines has been active in accelerating this trend toward more formalized OJT by developing generic materials for a wide variety of occupational skills. These materials serve as a foundation for industrial trainers to build on to upgrade their training. By providing basic documentation (performance criteria) and course materials, individual companies can incorporate additional site-specific information they feel is necessary. Such latitude enables more efficient and effective use of the training resources. In this way, the trainer can more quickly develop a higher quality, performance-based program. Additionally, developed materials serve to specifically aid smaller companies. Due to economics of scale, they have not historically invested in formalization to the extent of major corporations.

The following sections of the paper briefly describe current programs being developed under Bureau of Mines contracts.

EQUIPMENT OPERATION--DEEP MINING

These materials were prepared to provide documentation through the collection of task data and the identification of training objectives and job performance criteria. Instructional strategies for these training materials are determined by an assessment of user needs, specific population characteristics, and ease of customization.

Hoist Operator Training

Training materials have been prepared in modular form covering a wide range of hoist operator duties and responsibilities (contract H0387003). The materials were specifically designed to be used in conjunction with hands-on operating experience.

The program is divided into three parts. Part I (23 instructional units) provides the trainee with background knowledge of the hoist components and describes hoisting procedures.

This part requires approximately 20-24 hours of classroom instruction or self-study. It includes several units addressing each of the following topics:

Descriptions of all hoist components.

Federal rules (30 CFR, Part 75 and 57) that refer to hoisting.

Description of hoisting procedures.

Description of inspection and maintenance procedures.

Descriptions of electrical equipment.

In part II, the trainee becomes familiar with the specific characteristics of the hoist(s) that he is being trained to operate. He, with the trainer, will go to the hoist equipment and note the specific types of equipment (ac or dc drive, single or double drum, drum or Koeppe wheel, disk or

hand brakes, etc.), and the location of the components of the hoist. A check-off list is provided and can be used by the trainer as a guide to assure that all parts of the hoist are covered.

In part III, the trainee will, under the guidance of an experienced hoist operator or hoist supervisor, become proficient in operating the hoist.

Continuous Miner Operator Training

Task analyses and first generation materials are complete (contract H0377025). Training materials were developed as classroom support for a training system involving OJST and OJT. The OJST included slide-tape material, workbooks, an instructor's guide, and a part-task trainer-simulator. The part-task trainer and materials are type specific to a Joy 12CM. As such, only a few of the training modules are considered generic and supportive of formalized OJT.

Current efforts entail modification of the materials so that they can be more easily customized for other equipment makes and models and verification of classroom and OJT performance criteria.

Roof Bolter Operator Training

Task analyses are complete and developed materials are ready for field review and validation (contract H0188039). The training program includes the use of audiovisual material, student worksheets, on-the-job aids, and an instructor's guide detailing procedures for conducting classroom and OJT. The training materials were designed to address a wide variety of bolting equipment and are suitable for either group or individual instruction.

Shuttle Car Operator Training

The shuttle car program will be a demonstration model of a complete and systematic OJT process incorporating conventional OJT procedures (preparation, presentation, application, and followup) with social learning theory (behavior modeling and imitative-type learning procedures). The program will include materials directed toward the OJT trainer and trainee.

The training program (contract H0308028) for shuttle cars will include: (1) materials to be used in a self-study or classroom environment (OJST), (2) specific instructions and exercises for the trainee in the conduct of OJT tasks, and (3) detailed training and instructions for the trainer in developing, evaluating, and reinforcing trainee performance.

Metal and Nonmetal Mining Equipment

This effort (contract H0380867) provides for the preparation of basic documentation for selected occupations unique to deep metal and nonmetal mines. Materials preparation will address a variety of activities including feedleg drills, barring down and scaling, jumbo drills, locomotives, load-haul dumps, overshot loaders, rockbolting, slushers, supply handling, and personnel carriers.

EQUIPMENT OPERATION--SURFACE MINING

A six-element training program is being used as a standardized instructional model for operators of surface mining equipment. The training elements include:

1. Equipment orientation. This element introduces the trainee to the work cycle which he will be a part of in the production process; discusses company safety rules and procedures for specific equipment types; and identifies performance expectations of the job. This training element is a key opportunity in assuring the trainee of the employer's concern for worker health and safety.

2. Personal protection. The second element discusses use of personal protective equipment including design limitations of rollover and falling object protective devices, and the importance of inspection procedures. In addition, the proper use of the seat safety belt and other protective devices on the equipment, such as fire suppression and noise reduction devices, are also covered in this element.

3. Preshift inspection. This element presents the trainee with structured training and a checklist for conducting a walkaround inspection, and machine startup and checkout procedures. Topics include tires and wheels, lights, fluid supply levels, fluid line condition, engine compartment condition, fire extinguishers, windows, mirrors, backup alarm, gages and warning lights, engine operation, brakes, steering, retarders, and bucket, bed, or blade operation.

4. Basic operation. Instructional material for this element is concerned with preparing the trainee to operate the piece of equipment. It addresses those basic tasks that are necessary for production work in a relatively controlled environment.

For the most part, this material is adapted from manuals developed by mobile equipment manufacturers and augmented by procedures developed by mining companies and from accident research and task analysis that provide information to key areas of emphasis for developing required operational skills.

5. Advanced operation. This element (materials and structured OJT) seeks to identify those procedures and skills that need to be taught (transition training) as an integral part of the production process. This element transfers previously developed motor and cognitive skills to that part of operator training that is necessarily a part of production; for example, loading and dumping with the production unit.

6. Proficiency demonstration. The last element is a thorough test of operating knowledge, company procedures, and motor skills. The tests are administered by an instructor or supervisor and scored in terms of a performance standard. In addition to the materials and structured OJT, a device has been developed to simulate, in the equipment to which it is connected, certain abnormal operation conditions and to teach and evaluate operator response. This device, discussed in another paper in the proceedings, is called an OBSAC--an onboard simulator of abnormal conditions.

Development Status

Training materials addressing preshift inspection and personal protection (contract H0377101) are presently available for diesel, diesel-electric, and highway-rate haulers; rubber-tired and diesel-electric loaders; motor graders; scrapers and rubber-tired dozers; service tractors and highway-rated service trucks; and crawlers.

Materials are prepared in draft form addressing the six training elements for haulers (contract J0387221) and front-end loaders (contract H0308034). Drafts of the storyboards, audiovisual materials, instructor's guide, and trainee evaluation procedures will be field tested in 1981. Final material are expected to be completed in September 1981.

Current development efforts (contract H0318009) are addressing the collection of task data and ultimately, materials preparation for the balance of training elements and equipment types itemized in table 1.

TABLE 1. - Status of training element development

Equipment	Training Elements					
	1	2	3	4	5	6
Haulers	S	X	X	S	S	S
Front-end loaders	S	X	X	S	S	S
Graders	D	X	X	D	D	D
Scraper	D	X	X	D	D	D
Hydraulic excavators	D	X	D	D	D	D
Drills	D	X	D	D	D	D
Service trucks	D	X	X	D	D	D
Crawlers	D	X	X	D	D	D

X Completed.
S Available by September 1981.
D In development; available 1982-83.

SPECIALIZED MINING SKILLS

Instructional materials, in various stages of development, are being prepared for a variety of mining tasks requiring a specialized skill. The research goal is to develop instructional materials and procedures that allow for skills development based upon performance objectives.

Materials to be field tested and evaluated in 1981 include mine rescue team training, surface mine blasting procedures, electrician training, and underground fire fighting. Training programs addressing mine construction (shaft sinking) will be completed in 1982.

CONCLUSIONS

Efforts discussed in this paper are directed toward assisting the industrial trainers in their efforts to formalize instructional methods, to evaluate training program effectiveness, and to enhance skills development for

a wide variety of mining occupations. The research goal is to develop and validate performance objectives. Achievement of this goal requires a systematic approach to the analysis and use of a needs assessment, the specification of instructional objectives, the use of controlled training experiences (both classroom and OJT), and the identification of a performance criteria. Once evaluation procedures are established, the findings can be used to improve the training process. The results of this ongoing research will significantly enhance the effectiveness of the training opportunities available to the mining population today.

CURRENT RESEARCH IN THE APPLICATION OF TRAINING EQUIPMENT SUPPORTING EQUIPMENT OPERATOR TRAINING

by

William J. Wiehagen[1]

ABSTRACT

Long-term education and training research seeks to apply learning and simulation technology, particularly that developed by the military, to the training of new operators of surface and underground mining equipment. The research objective is to investigate the potential for accelerating skills acquisition.

This paper discusses the status of three research investigations oriented toward this objective (1) A full-task simulator for underground haulage equipment; (2) a part-task trainer for continuous mining machines; and (3) an onboard training device or aid for mobile, surface mining equipment.

INTRODUCTION

Increased sophistication and cost of mining equipment provide incentive for investigating methods to enhance human performance. These methods require application of human factors and training technology and often result in careful consideration of equipment, work station, and control design; operator training and selection; and performance-based supervision. The need for an interdisciplinary research approach is further amplified by the mining environment whereby man-machine combinations and interaction require close and continued attention due to restricted and congested work space.

Training is an integral component of interdisciplinary research directed toward methods to affect human behavior. Research support for a systematic and formalized approach to the development of operator skills can be summarized as:

1. Accident analyses highlighting the relationship of task experience to injury frequency. Safety studies conducted during the past decade for surface and underground mining equipment cite higher accident frequency rates for new machine operators than for experienced workers.

2. Industrial safety research indicating that:

    a. Training has an apparent effect on reducing injury risk during initial months of task performance, but, in most cases, does not completely eliminate the higher initial accident risk as compared with levels achieved by veteran workers.

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b. Training has an apparent effect in accelerating the acquisition rate of safety skills that also occurs on a more casual basis during informal on-the-job training (OJT).

c. Training has no apparent long-term effect on accident rates; that is, the effect of initial training is either heightened and reinforced or tempered by on-the-job work practices. Initial job or employment training is not the determining factor in maintaining long-term work behaviors.

The purpose of this paper is to describe and discuss the development of prototype training equipment for selected types of surface and underground mining machines. These trainers are not viewed as replacing but supplementing and enhancing on-the-job instruction. The research hypothesis common to each project is that by investigating methods to further concentrate and accelerate skills acquisition and by developing tools (documentation and measurement techniques) encouraging proficiency-based training, significant reductions in average training times will be achieved. Reducing training times and broadening the scope of training to address operator behavior under emergency situations will hopefully contribute to reducing machine operator errors during initial months of task performance.

SHUTTLE CAR TRAINING SYSTEM

A prototype shuttle car training system (SCTS) was developed by ORI, Inc., under contract H0272039 with the Bureau of Mines. This effort provided for the design and development of a reaction trainer (simulator), training aids, student materials, and an instructor's guide. Plans are presently underway to locate the system at a field site for the purpose of system checkout and field testing. Although the prototype equipment is designed to simulate a shuttle car, the system could be adapted to simulate other types of underground haulage equipment (locomotives, personnel carriers, and scoops).

Functional Description

The SCTS is a full-task training device providing adequate fidelity to learn and practice basic perceptual, decisionmaking, procedural, and manipulative skills. Trainee utilization is expected to provide control, familiarity, and practice in procedures associated with tramming, turning, loading, and dumping. Additional potential includes practice in the recognition and response to hazardous conditions and other operational contingencies. Major components of the trainer are identified in figure 1 and portrayed in figures 2 and 3.

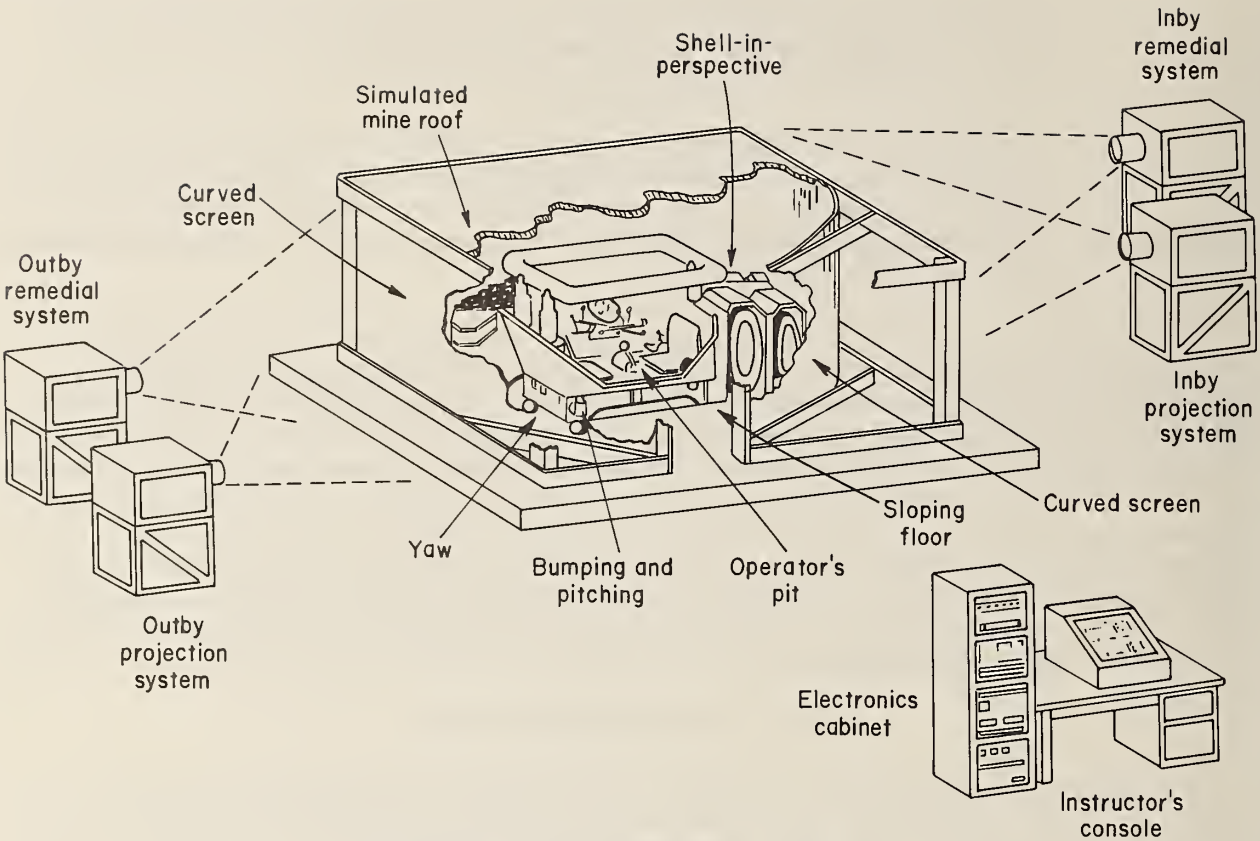

FIGURE 1. - Reaction trainer—simulator.

The operator station replicates that of a NMS Torkar with manual transmission. All controls are monitored by the computer for position and status.

Inby and outby visual systems consists of a U-shaped, wraparound screen, a foreshortened shell of the shuttle car, and a variable speed 16-mm motion picture projector. The operator station and shell-in-perspective is mounted on a low-profile motion base providing realistic simulation of bottom conditions and lateral translation (yaw) contingent upon steering inputs and vehicle speed. The geometry of the screen and shuttle car shell provide a tight fit whereby the screen is wrapped around the shell-in-perspective. The geometry of the mine, the filming technique, and the projection technique combine with the wraparound screen, shuttle car shell, and yaw (rotation) to provide environmental simulation that enables the operator to perceive and judge parallelism, to judge the relationship of the shuttle car with respect to corners and intersections, and to maneuver the shuttle car through the work section.

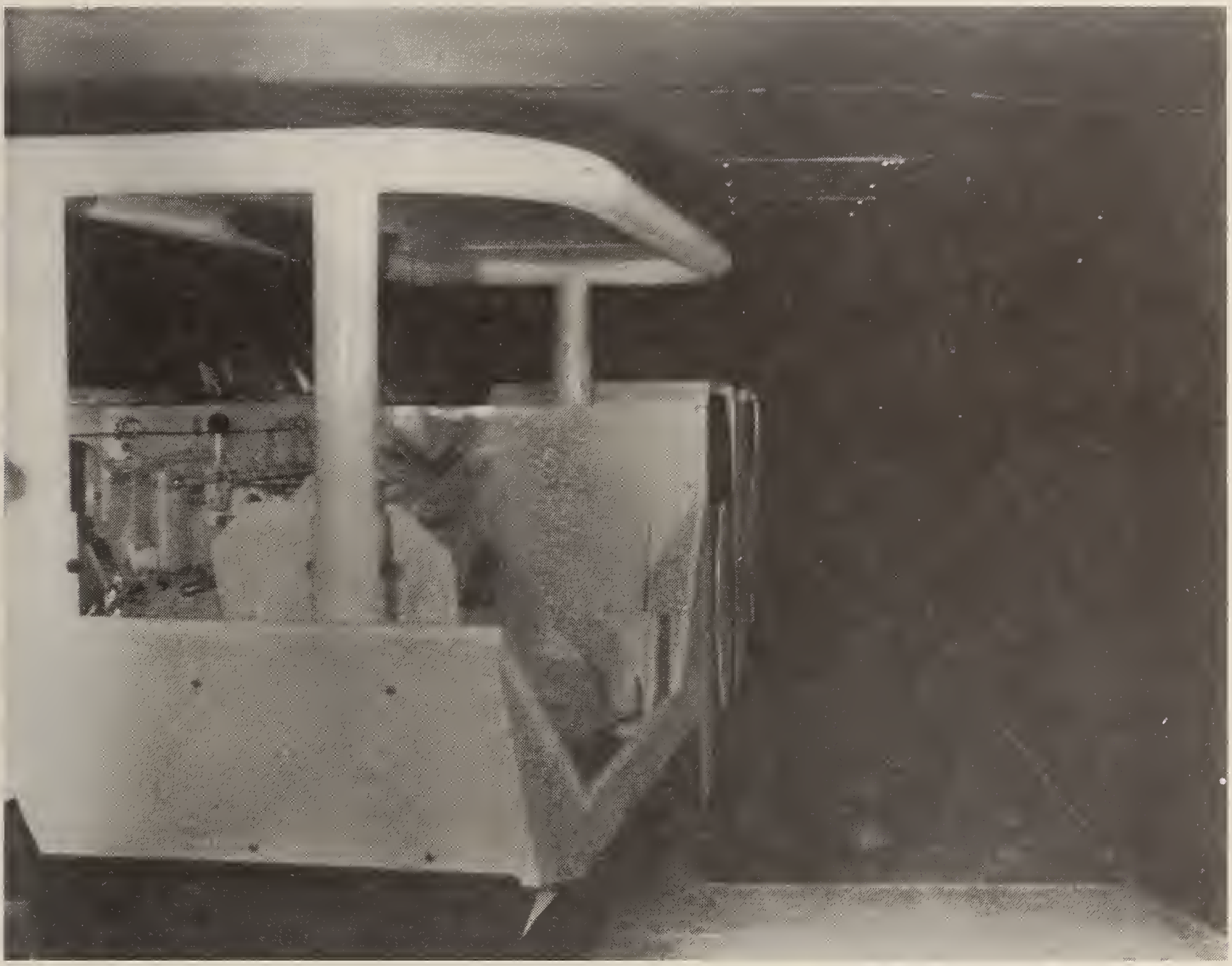

FIGURE 2. - Simulated shuttle car.

An integrated sound and vibration system, under computer control, provides cues as to the status of pump motor and tram position.

Remediation routines, available from a random access library of slide-tape (ST) presentations, provide instruction relative to a particular exercise, reinforcement for correct action, and reminders and remediation for incorrect trainee response.

The instructor's console provides a profile of the trainee mastery of procedures and skills and utilizes the data, along with observational data from instructor coaching activities, to assess trainee progression through the course.

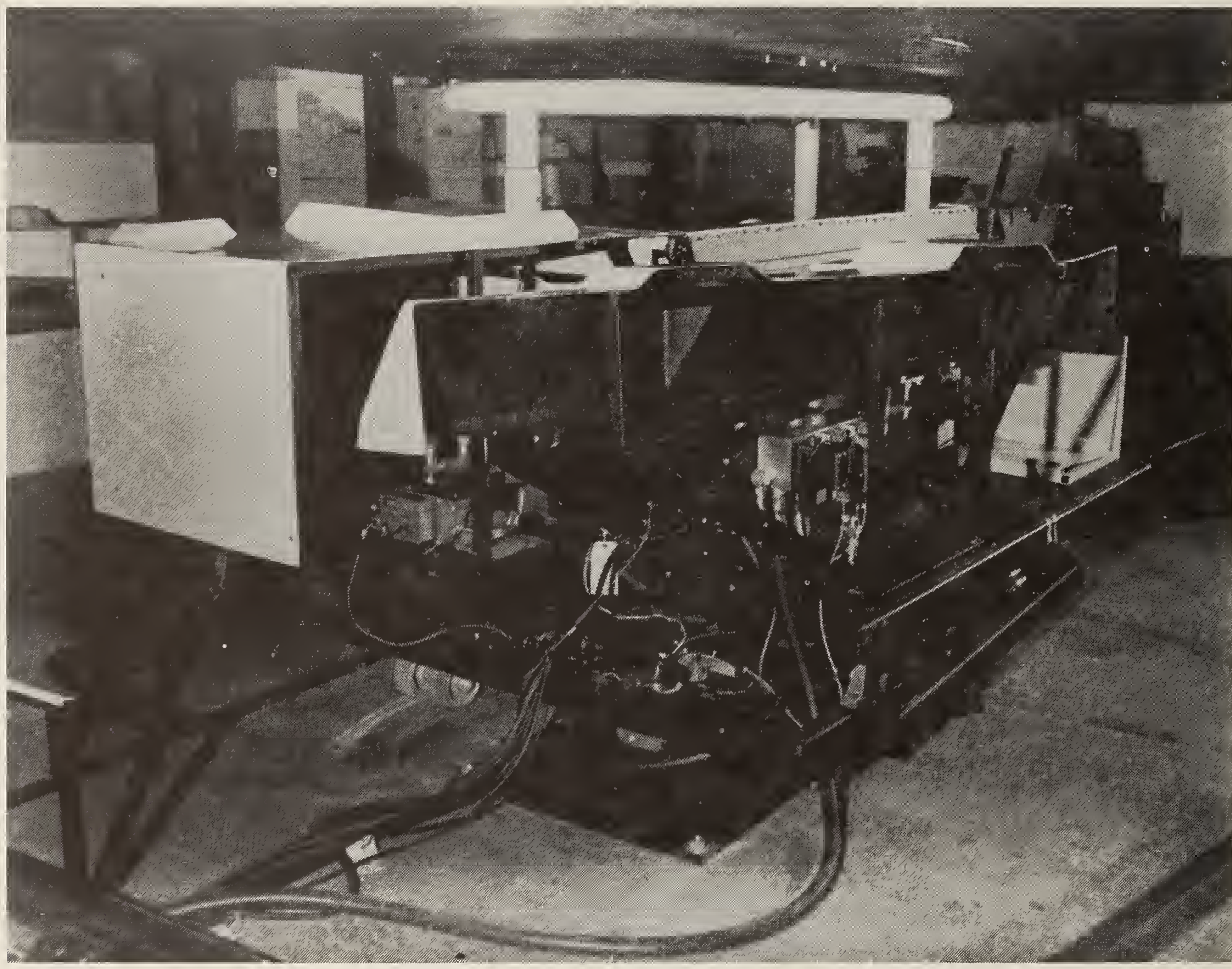

FIGURE 3. - Motion base.

The computer system receives basic inputs from the instructor's console, shuttle car controls status from the operators pit, precise simulated geographical location data from the visual system, and status of the ST remedial system. The computer uses these data to compute and control simulated tramming and maneuvering, to monitor adherence to procedures, to activate the remedial system as appropriate, and to provide an operator profile to the instructor.

Simulator Exercises

The prototype system includes a library of 12 exercises. The average time per exercise is expected to be approximately 45 minutes. The exercises progress from basic manipulative skills with little task loading through adherence to routine procedures with increased task loading to hazards and contingencies under maximum task loading conditions.

CONTINUOUS MINER TRAINER

A prototype continuous miner training system (CMTS) was developed by McDonnell Douglas Electronics Co. under contract H0377025 with the Bureau of Mines. This contract provided for the design and development of a part-task and procedures trainer, student materials, an instructor's guide, and a maintenance manual. The CMTS is presently installed at Rend Lake College, Ina, Ill., for the purpose of system checkout and field demonstrations.

Functional Description

The CMTS is a combination procedures and part-task training device. Trainee utilization is expected to provide familiarity with the controls, operating procedures, and mining application of a typical continuous miner. Major components of the trainer are identified in figure 4 and portrayed in figure 5.

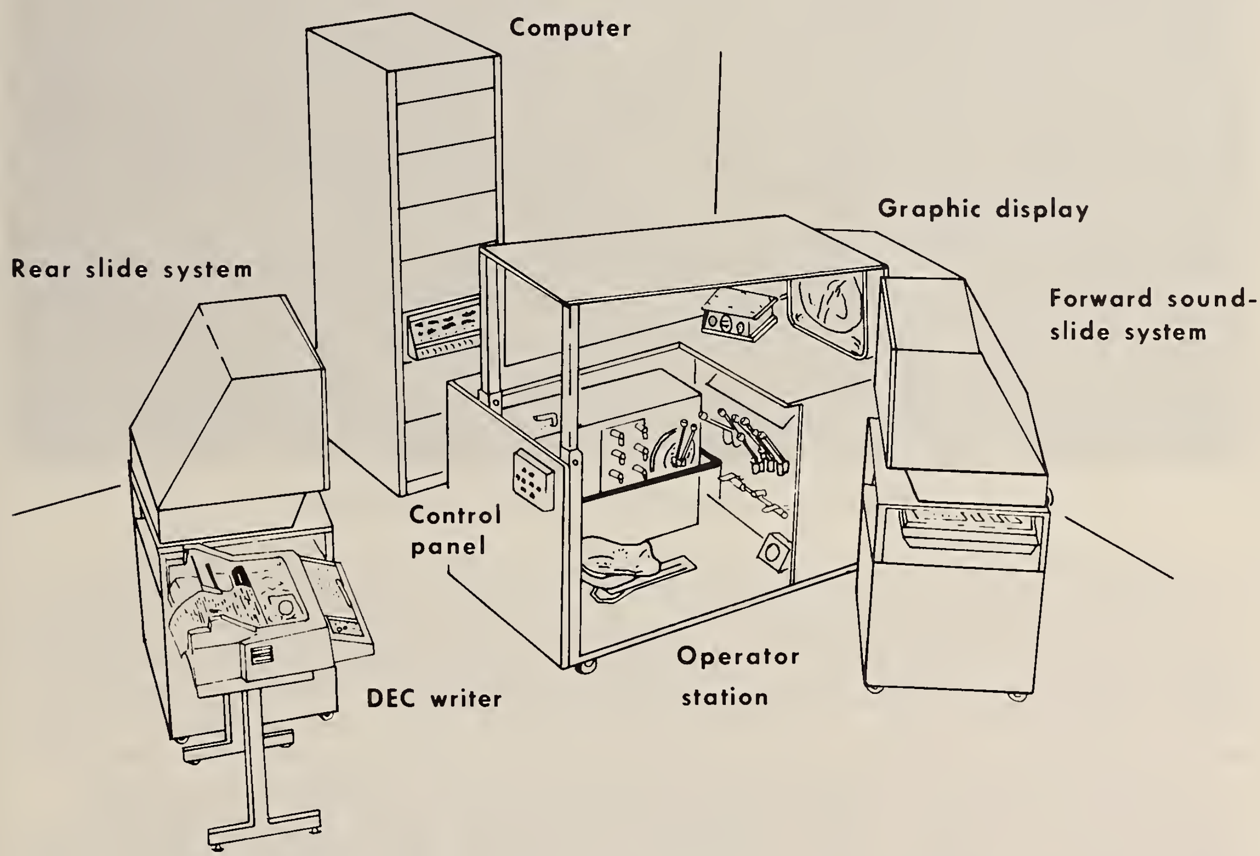

FIGURE 4. - Continuous miner part-task trainer components.

FIGURE 5. - Continuous miner part-task trainer.

The operator station mimics that of a Joy 12CM continuous miner. Manipulation of the controls result in movement of a graphic representation (fig. 6) of the continuous miner projected on the graphics display in approximately the same manner and rate of response as would be experienced on the actual equipment in underground operation. Functional controls include tram levers, cutterhead controls, gathering head controls, conveyor and conveyor boom controls, stabilizer jack, and water spray. Also included are the control and cutterhead circuit breakers and the electric switches to energize the pump and traction motor, conveyor, headlights, panic bar, tram safety pedal, and the monitor. The position of the water spray and fire suppression valves in the operator's station are monitored by the computer to insure proper trainee operation.

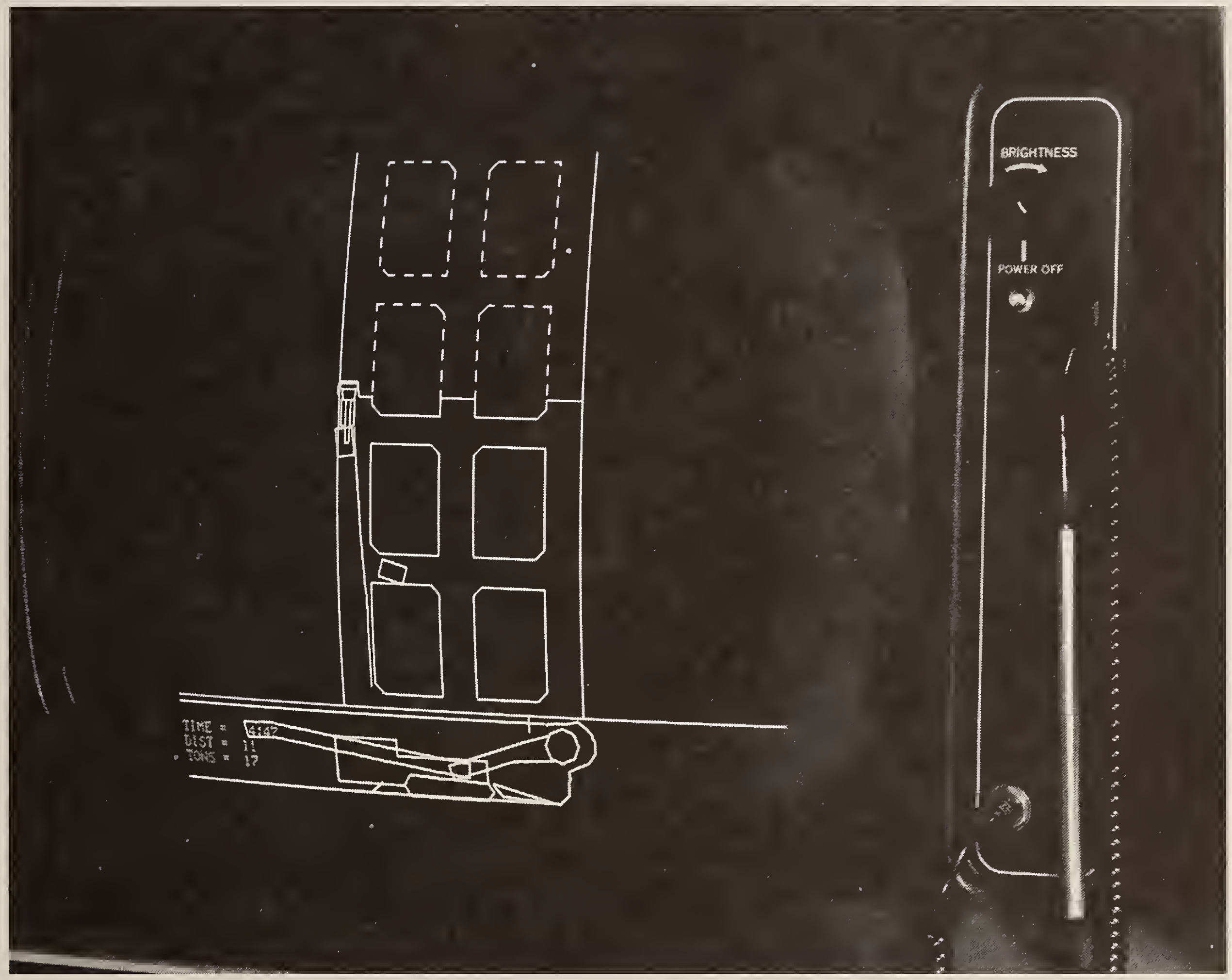

FIGURE 6. - Graphics display (top and side view).

Training tasks, student feedback, and recordkeeping are controlled by a PDP 11/34 digital computer. All of the electrical circuit breakers and hydraulic control lever positions are input to the computer which processes the input signals, simulates the continuous miner interlock and control logic, outputs signals to the graphics display, and cues the appropriate sounds and slides.

During the training sessions, the computer manages remedial instruction by informing the trainee of various performance errors. These are displayed on the graphics display and on one or both slide projectors. On the graphics display, a signal is flashed at the point of contact if the trainee accidentally strikes the roof, rib, or bottom with some part of the machine. A performance record is also available in hard copy at the instructor's request.

The trainer utilizes an interactive computer graphics system. The basic information relating to dimensions of the mining section, including pillars, entries, crosscuts, and coal faces is stored in memory along with the essential configuration details and tram speeds of the continuous miner and a shuttle car. These data are processed in the computer and applied to the graphic terminal. Dynamic or motion inputs resulting from manipulation of the operator's controls are similarly processed in the computer to update the graphics file. The graphics system then presents a continuous, nonflickering display showing a relatively smooth movement of the continuous miner and its related moving parts. Figure 7 demonstrates a turning task and figure 8 shows the continuous miner during the cutting and loading cycle.

Primary function of a forward and rear sound-slide projection system is to respectively display procedural error conditions and depict conveyor boom positions, helper location, and shuttle car loading activities.

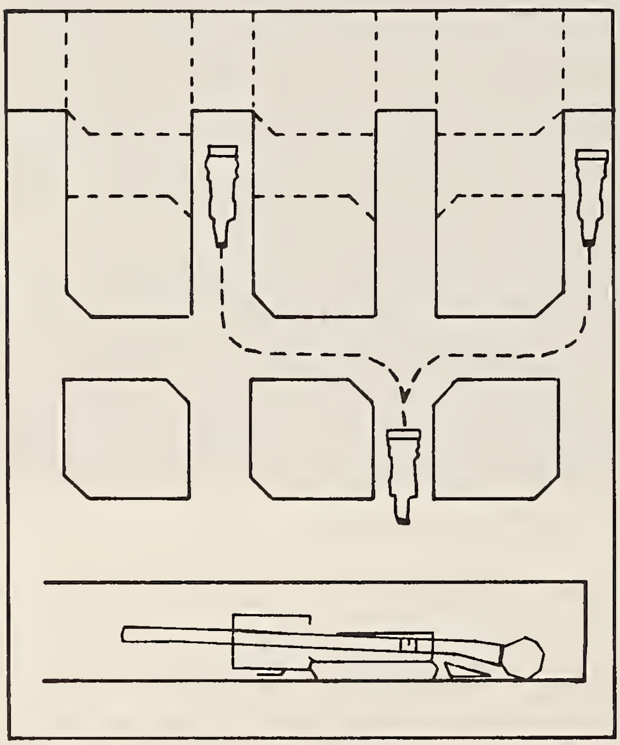

FIGURE 7. - Turning task.

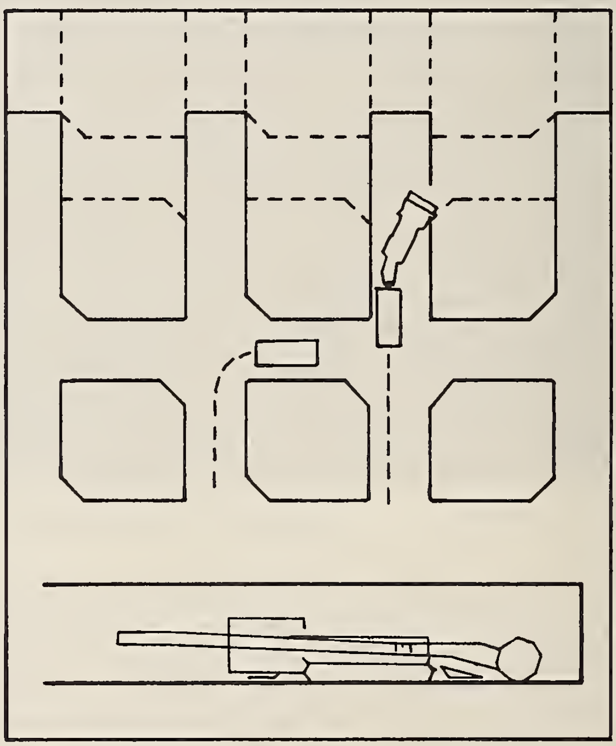

FIGURE 8. - Coal cutting—crosscut.

An integrated sound system, under computer control, allows for six basic sound effects: hydraulic pump, tramming, cutterhead rotation, cutting coal, cutting rack, and conveyor loading coal. An instructor's console provides for management of the trainer exercises. Instructor inputs are either delivered verbally to the trainee or entered into the computer via the DEC writer.

Trainer Exercises

Several training exercises have been developed, stored on a floppy disk, and used in the initial demonstration of the CMTS. These exercises cover the following areas of continuous miner operations:

1. Control operation and startup procedures.

2. Tramming and turning.

3. Cutting and loading coal.

4. Turning a crosscut.

5. Shutdown and parking procedures.

ONBOARD SIMULATOR OF ABNORMAL CONDITIONS

A prototype training device for mobile surface mining equipment was developed by Woodward Associates under contract H0377101 with the Bureau of Mines. This effort provided for the development of an On-Board Simulator of Abnormal Conditions (OBSAC), training materials, and an instructor's guide. Field testing and validation of the training system is presently underway at surface mines in Kentucky and Arizona. The prototype equipment has been installed on two models of haulers and front-end loaders.

The training system combines classroom training (OJST) with structured OJT. Content areas for the classroom and on-the-job elements are discussed in another paper in the proceedings, but briefly include: (a) equipment orientation, (b) personal protection, (c) preshift inspection, (d) basic operation (e) advanced operation, and (f) proficiency demonstration.

Supporting the material prepared for basic and advanced operation as well as the proficiency demonstration is a device to simulate, in the actual equipment, certain abnormal operating conditions of the equipment to which it is connected. Figure 9 depicts a development prototype of the OBSAC console. The OBSAC, which is electrically connected to mobile equipment via an adapter kit, allows the instructor to control the readings of certain gages, actuate visual and audible alarms, and degrade braking and steering performance. Functional gages of the OBSAC prototype include: water temperature, oil pressure, voltmeter, transmission-converter oil temperature, transmission-clutch oil pressure, starting air pressure, and brake air pressure. A digital stopwatch, part of the console, enables the instructor to determine the reaction time of trainees to observe an emergency or abnormal condition and initiate the proper action.

FIGURE 9. - OBSAC console.

Onsite training (fig. 10) for basic and advanced operating procedures as well as the proficiency demonstration will utilize the OBSAC console.

The OJT exercises are presently being prepared.

FIGURE 10. - Onsite training with OBSAC.

CONCLUSION

The development of prototype training equipment discussed in this paper has followed a systematic approach emphasizing the specification of task requirements, instructional objectives, controlled training scenarios (OJST and OJT) for fulfilling these objectives, and criteria for performance.

The status of each project is consistent in that current and future research investments need to address the collection of evaluative information as to current utilization and the possible improvement of the prototype equipment.

Many studies have indicated that how a training device is used has more influence on learning and transfer of training than the design of the device itself. Utilization of the training equipment must involve the entire "system" in which the device itself will only serve some well-defined purpose within the larger framework.

Current research objectives are directed toward the goal of documenting specific procedures and scenarios for both the OJST and OJT elements. Once the training devices are effectively used in addressing, in part or in total, the achievement of performance skills, transfer of training and cost-effectiveness of the training equipment can be better assessed.

A NEW LOOK IN ORGANIZATIONAL DEVELOPMENT TECHNOLOGY

by

Robert S. Atkin[1] and Paul Goodman[2]

ABSTRACT

This paper summarizes research sponsored by the Bureau of Mines, Department of Commerce, and the Ford Foundation, relative to organizational development activities in the mining industry. Three research studies are discussed and conclusions drawn as to guidelines for successful organization change that can impact safety productivity, and work satisfaction.

INTRODUCTION

Since the early 1970's there has been a dramatic change in organizational development activities. Although most of the new look in organizational development has occurred in nonmining industries, some has occurred in mining. The purpose of this paper is to review briefly three completed studies in mining that have examined new-look activities.

The characteristics of this new look in organizational development include:

Increasing sophistication. - The technology of training is becoming more sophisticated. To achieve better safety and productivity, more complicated learning techniques and combinations of techniques are being applied. Techniques such as needs assessment and social reinforcement theory are being used to modify, structure, and augment the traditional, informal on-the-job training typical of the past.

Organizational Restructuring. - There is a shift from relying solely on training to bring about desired changes in worker behavior. The new focus is on training with other organizational changes to improve organizational effectiveness. The critical assumption is that training and a complementary set of organizational changes may increase safety, productivity, and work satisfaction; whereas training alone will not be sufficient. By complementary organizational changes, we mean changes in authority, communication, and pay systems that are congruent with the training. For example, as described later in this paper, a study of underground coal mines found that organizational climate affects injury experience. Another study conducted in an underground bituminous mine found that training was complemented by changes in organizational structure.

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Total System Changes. - There is also a shift from emphasis on changing the worker to emphasis on changing the total organizational unit. The assumption here is that unless changes are brought about in the attitudes and behavior of top and middle management and firstline supervisors, it is unlikely that any change in worker behavior will appear.

Developments in Evaluation Technology. - There has been substantial progress in the technology of organizational assessment. This technology, which has developed over the last 8-10 years, permits us to evaluate the effects of organizational development efforts. Any significant organizational development represents a major financial and psychological commitment. Managers now have the means of assessing the costs and benefits of organizational development.

Extent of changes. - This revolution in organizational development activities has cut across all industries. It appears in large and small organizations, profit and nonprofit organizations, unionized and nonunionized organizations, and in new as well as existing organizations. City government, military agencies, automobile manufacturers, hospitals, etc., have all attempted to find new combinations of training and organizational restructuring as a way to improve safety, productivity, and work satisfaction. It seemed appropriate, therefore, that the mining industry might apply relevant findings from these developments. The following three projects were designed with this in mind.

THE EFFECTS OF ORGANIZATIONAL CLIMATE AND POLICY ON COAL MINER SAFETY

Introduction

The first project to be reviewed demonstrates the importance of organizational and managerial factors to safety. This study is not an organization development intervention but rather points to the need for such intervention. The project, entitled "The Effect of Organizational Climate and Policy on Coal Mine Safety"[3] was funded by the Bureau of Mines in 1974.

Sample Selection of Mines

Virginia, Kentucky, Pennsylvania, and Ohio were selected as representative study areas based on data for 1972 and 1973 on the injury rates and manpower of all underground bituminous coal mines in the United States. To insure a definite management structure and uniformity of exposure, mines in these states having at least 80 employees for 1972 and 1973 and working 1,600 manhours per man were selected to form a sampling pool. After percentile ranking of injury rates, mines in the top and bottom 30 percent of the industry for the two report years were proportionately selected within each state to insure a wide differential in accident rates. Percentile criteria were relaxed until the necessary number of mines in each state was obtained

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[3]U.S. Department of the Navy. A Survey of Physical Tasks that Affect Mine Safety. BuMines OFR 108-77, July 1976, 180 pp.; available from NTIS, PB 267 781.

and cooperation agreement reacted. To provide variation in management philosophy, no more than two mines operated by the same company were sampled.

Hypotheses

Based on the literature, the following general hypotheses were examined:

1. Mines in which management shows concern for the workers and their working conditions will tend to have a low incidence of unsafe behavior and injuries.

2. Mines in which management puts pressure on workers for increased production will tend to have a high incidence of unsafe behavior and injuries.

3. Mines in which management plans effectively will tend to have a low incidence of unsafe behavior and injury.

4. Mines in which the miners have good morale, identify with the organization, and have a high achievement motivation will tend to have a low incidence of unsafe behavior and accidents.

5. Mines in which miners are given decision responsibility and autonomy will have a low incidence of unsafe behavior and accidents.

6. The better the safety attitude of the workers and management, and the more safety knowledge possessed by the miners, the lower will be the incidence of unsafe behavior and injury.

In summary, the 22 mines visited seem representative of other mines in the country in terms of injury rate, but probably include more larger (that is, more manpower, more production) mines than would be typical. However, the amount of bias is probably small, considering the number of employees. The average work force in 1972 for all 166 mines included as possible candidates for study was 227, while the 22 mines actually studied has an average of 257 men. In 1973, the average for all mines was 228; for the 22 mines visited, it was 264.

The original criteria for selected mines with more than 80 employees in effect guaranteed a sample of relatively large mines. The results and conclusions of this study, therefore, may not generalize to smaller mines.

Sample Selection Within Mines

Each of the 22 mines was visited by a data collection team between September 1974 and July 1975. It required 10 months to collect the data because of scheduling problems and a nationwide coal strike occurring during that period.

At each mine, a sample of miners from two shifts was selected. Attempts were made to secure a random sample of miners, but this was not always possible. The number of miners sampled at each mine varied from 10 to 27. The miners were given a questionnaire in groups either just before the shift or at the conclusion of the shift. Each miner was paid $10 as an incentive to participate.

The data were collected at two points in time separated by 5 to 8 months.

Data Collection Techniques

The principal data collection techniques included: an organizational-climate questionnaire (for miners); an abbreviated climate questionnaire (for mine superintendents); structured interviews (for mine superintendent, foreman, safety committee); company records on injury rates; and a safety questionnaire (for state mine inspector).

Climate questions examined miners' perceptions of decision decentralization, share autonomy, worker autonomy, management receptiveness, production pressure feedback, performance-reward dependency, development of new and continuing employees, consistency of management orders, management supportiveness and concern for working conditions, worker morale and identification with company, achievement motivation, cooperation among workers, safety knowledge and attitudes toward safety by both management, and other similar issues.

Analysis Plan

There were two essential elements in the analysis plan. First, the basic analysis plan uses a cross-lagged correlational design (fig. 1).

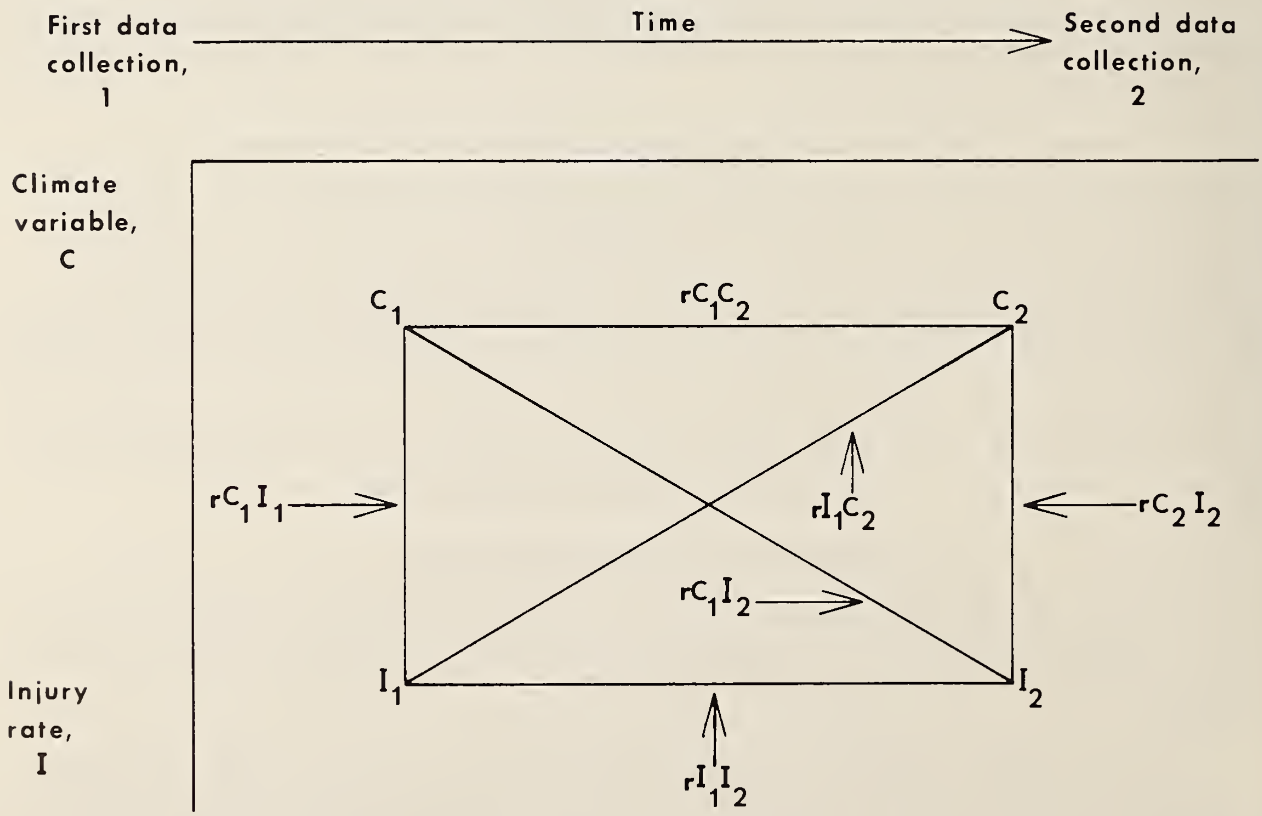

FIGURE 1. - Correlations used in time-lagged design.

Correlations Used in Time-Lagged Design

This design compares correlation coefficients at two points in time among the independent and dependent variables. For example, one method used to determine whether climate affects injury is to compare the relative size of the coefficients rC_1I_2 and rC_2I_1. The general hypothesis, then, in this project is that $rC_1I_2 > rC_2I_1$ for those climate variables expected to be affected by injury experience.

The second analytic strategy was to cross-validate the results based on eight newly chosen mines. The purpose of the cross-validation was to assess the stability or generalizability of the results.

As predicted, the cross-validation data matched almost perfectly the first round data obtained in the original cross-lagged study. Only one variable (safety knowledge) showed a statistical difference ($Z = 2.38$, $p<0.01$) between the cross-validation and first round cross-lagged data. With 32 variables, one would expect at least one comparison to be unreliable by chance alone. It can be concluded with confidence that the data collected on the cross-validation sample match the data first collected in the original mines. This strongly suggests that the original data possess considerable generalizability.

Results

The major purpose of this study was to determine if organizational climate and management practices influence injury experience in underground coal mines.

Specifically, the data suggest that:

1. When decisions are decentralized, when management is flexible and innovative in trying new procedures and programs, and when morale is high, disabling injuries decrease.

2. As disabling injuries increase, feedback, continued employee development, and consistency of orders improve, which appears to decrease injuries.

3. Production pressure seems to lead to an increase in disabling injuries that, in turn, result in a decrease in production pressure.

As a byproduct of collecting the injury data and determining its validity, inconsistencies were noted in the reporting practices among various mines. These inconsistencies concerned how injuries were classified and what was included in the man-hour figures reported by mines.

Conclusion

A basic conclusion from this study is that the organizational climate and managerial practices affect injury rates, and further, that injury experiences have an effect on other climate and managerial issues. Therefore, in order to reduce accidents, one must not only focus on the worker but also on the broader organizational and managerial context within which the miner works.

THE EFFECTS OF APPLIED BEHAVIORAL ANALYSIS AND APPLIED BEHAVIORIAL MANAGEMENT TECHNIQUES ON SAFE BEHAVIORS OF SALT MINE PERSONNEL

Introduction

The second project focuses on the effects of applied behavioral analysis and applied behavioral management techniques on the safe behavior of salt mine personnel. The first project indicated that managerial practices can affect safety behavior. This study[4] shows how certain training techniques can change managerial practices. This project with resultant training materials (positive motivational safety training) was also funded by the Bureau of Mines.

Description of Sample

For this study, the Salt Institute selected five firms that would each make a plant available for the experimental aspects of the study. Site selection was based on the following criteria: The sites were to have high injury frequency and severity rates; be of similar size; have similar production rates; include at least two mines; be willing to let all plant management participate in the training phase of the study; provide data as needed; and agree to implement the training program.

Five other sites were selected as controls. The criteria for their selection included: close proximity to the experimental site (cultural control); similar accident-injury severity and frequency rates; similar production of salt by tonnage; monthly accident-injury reports; and ownership by a firm other than the experimental plant for which they were the control.

Nature of the Program

Each experimental plant received training according to a schedule that did not interfere with production. There were some occasions when two full days were set aside for training, while there were others in which only half days were available. As is often the case with field experiments or demonstrations, numerous trips to each plant were necessary to complete all training.

The training program called positive motivational safety training was based on social reinforcement theory. The basic elements in the program include:

<u>How To Recognize Unsafe Behavior (1 Hour)</u>. - Learning skills in observing how a worker actually performs his job.

<u>How To Develop Behavioral Baselines (20 Hours)</u>. - Learning to count and record behavioral observations to provide measurements of change.

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[4]Salt Institute. Study of the Effects of Applied Behavior Analysis and Applied Behavior Management Techniques on the Safety Behavior of Salt Mine Personnel. BuMines OFR 80-44, Sept. 30, 1978, 44 pp.; available from NTIS, PB 80-171309.

How To Determine What Behaviors To Change (2 Hours). - Learning to be specific about behavior. This permits supervisors to reinforce appropriate behaviors and alter inappropriate ones.

How To Communicate Behavioral Change to Workers (11 Hours). - Developing an awareness of interpersonal relationships, the communication process, and positive expression is the key to a successful change.

How To Shape Behaviors (4 Hours). - Combining all the preceding skills to make the supervisor skillful in bringing about new behaviors.

How To Maintain a Safe Work Behavior Program (2 Hours). - Knowing what to say and how to maintain the new behaviors.

The training program focused on shaping simple behaviors such as wearing safety devices, lifting correctly, using tools properly, maintaining housekeeping standards, etc. More complex behaviors such as suggesting better work methods, identifying unsafe conditions, and self-enforcing safety practices represented more complete behaviors that were included in the programs.

Results

The basic analysis design was to compare injury rates for the different experimental sites before and after training. One of the original sites was dropped due to labor problems and replaced by a sixth site (with control). This latter site ultimately was not included because of insufficient time after training to collect data. Another was dropped because man-hour data were not available. In two of the three sites the average injury rate decreased (table 1). Treatment group and control group comparisons were not appropriate because of significant differences among matched groups during the pretraining phase.

TABLE 1. - Experimental site average injury rates before and after training

Site	Injury rate		Difference
	Pretraining	Posttraining	
Cargill..........	0.143	0.118	-0.025
Diamond Crystal..	.078	.100	+.022
Hardy...........	.153	.071	-.082

Table 2 examines the same data in another format--the number of posttraining months in which the average injury rates were above or below the pretraining months. The same two sites again exhibit a decrease in average injury rates.

TABLE 2. - Number of months above and below pretraining average injury rates for experimental sites

Site	Months		Chi square
	Above	Below	
Cargill	2	10	[1]5.14
Diamond Crystal	9	7	2.50
Hardy	0	10	[2]10.00

[1]Significant at 0.05.
[2]Significant at 0.01.

Conclusions

The basic finding in this study is that positive reinforcement in the form of praise can be effective in reducing accident frequency and severity. The authors also recognize that other factors such as the level of union support for training and the degree to which all levels of management undergo training are important for the training program's overall success.

THE EFFECTS OF ORGANIZATIONAL RESTRICTIONS ON PRODUCTIVITY, SAFETY, AND WORK SATISFACTION IN A COAL MINE

Introduction

The third project, known as the Rushton Quality of Work Experiment, began in 1974 and was sponsored by the Department of Commerce and the Ford Foundation. At the time, it was probably the most comprehensive organizational development activity initiated in the coal industry.

Description of Sample

The Rushton Mine is located in Osceolla Mills, a rural area in north-central Pennsylvania. It is a four-section mine with an average force of 200 employees. The mine is owned by Pennsylvania Mines Corp., which is part of Pennsylvania Power and Light. All of the mine's production goes to the utility company. Organizationally, the mine runs as an independent operation with the day-to-day decisions made by the president of the mine and his superintendent. The major work areas are the four mining sections. Each section has three crews, each manned by a foreman. At the time of the organizational intervention a crew was composed of the foreman, six production workers (miner operator and helper, roof bolter and helper, two car operators) and a maintenance man.

Decision to Participate

Rushton is a United Mine Workers mine. The mine began operation in 1966 and was organized shortly thereafter following a bitter struggle between labor and management.

Why did labor and management decide to enter into a joint organizational development effort? For the union, the principal motivation was the desire to

find new ways to improve safety. The president of the mine was concerned with the influx of younger, better educated workers into the mining industry. He felt that the nature of the work and slow upward mobility would lead to alienation and difficulty in retaining able workers. His goal was to create an opportunity at work to develop professional multiskilled miners.

Management and union were brought together by two professors, Gerald Susman and Grant Brown, of Pennsylvania State University, and an expert in the British coal industry, Professor Eric Trist, of the University of Pennsylvania. In April 1974, the president of the company and the union signed a letter of agreement to try several new approaches to organizational development.

Nature of the Program

After the agreement was signed, a labor-management committee was set up at the mine to design, evaluate, and recalibrate the organizational development effort. The following goals and changes were instituted by the committee:

1. Increase productivity, safety job skills, and work satisfaction.

2. Changes to be introduced on a section-by-section basis.

3. Authority for daily production decisions to be delegated to the mining crew.

4. Foreman to concentrate on safety, planning, and coordinating activities (not on daily production decisions).

5. Job switching to be used to allow each member of a crew to learn all other jobs in the section.

6. Pay to be top rate and the same for all members of the crew.

7. Two workers to be added to each crew to do support work.

8. A joint labor-management committee (five union members and five management members) to supervise the change effort on each section.

9. All grievances to go to the joint committee prior to the traditional grievance procedure.

10. An extensive training program to be instituted.

11. A gain-sharing plan to be instituted.

Other changes, such as the introduction of different performance appraisal systems, and department-wide conferences, were also approved.

Significance of Change

The changes proposed and introduced by the labor management committee were far reaching. They represented multiple changes in the organization; that is, the pay, job communication, decisionmaking, and job bidding systems were each modified. They also represented an important commitment by management and the union to experiment with new forms of work organization and to move away from existing practices. The specific changes are not intended as a model for what a given management should introduce into its organization, but they do illustrate new approaches that labor and management can create jointly to improve organizational effectiveness.

Results

This organizational development intervention is analyzed in detail by P. Goodman.[5] Extensive data collected over a 3-year period and statistical analyses were used to study the effects of the intervention. The results presented are conservatively stated. They represent a scientific statement as opposed to inflated statements described in the popular press.

1. Productivity was increased by 3 percent.

2. Analysis of productivity benefits (in dollars) and the costs of the intervention indicate a slight positive benefit.

3. Job attitudes shifted in a positive direction.

4. Safety measured by a variety of indicators shifted in a positive direction.

5. The level of job skills in the work force increased.

Interpretation of the Change

While it is important to understand the results of any organizational development intervention, it is also important to understand the principles underlying the change. There are four conditions that facilitiated changes at this mine.

1. The miners received intensive training both at the introduction of the program (48 hours) and throughout the experimental effort (8 hours of training every 6 weeks). The cost of this training was included in the calculation of results 1 and 2.

2. Some of the organizational changes (for example, job switching, greater responsibility, departmental conferences) provided the workers with a new set of rewards (safety, responsibility, feedback, ground identification) for performing more safely.

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[5]Goodman, P. Assessing Organizational Change: The Rushton Quality of Work Experiment. John Wiley & Sons, Inc., New York, 1979, 391 pp.

3. By focusing the foreman's role on safety rather than production, the miners received less criticism for doing safety work. Before the program, the pressure was for production versus safety activities.

4. The new set of rewards (variety, autonomy, responsibility, feedback) were valued by the work force.

Conclusions

The Rushton Quality of Work Experiment was one of the most extensive organizational development efforts in mining. It represents a shift in focus of organizational development activities. The change mechanism involved not only the miners but the organizational system surrounding them. Moreover, the project was thoroughly evaluated.

Since this was an experiment, our interest is not only in the results but in why the results occurred and other lessons to be learned. The basic principle is that the organizational activity increased the level of knowledge and worker motivation, which, in turn, affected safety, productivity, and work satisfaction.

The changes also generated problems. There was increased stress on first-line supervisory and management personnel. Conflict arose within the local union and between the local and international. The consultants failed to train organization members to run the change effort after their departure from the organization. The existence of these and other problems (cited by Goodman) are not surprising given the experimental nature of the project. The real issue is to be aware of such problems and manage them during the course of the change effort.

CONCLUSIONS

The basic thesis of this paper is that there has been a dramatic change in organizational development activities designed to improve the utilization of human resources. Essential to the new look in organizational development activities is the emphasis on the joint introduction of new training techniques and complementary organizational changes. Although these types of organizational interventions are new to the mining industry, the results indicate that they can increase safety, productivity, and work satisfaction.

In view of the experimental nature of the projects described here, no clear, definitive policy statements have been attempted. However, the following guidelines seem appropriate:

1. Prior to any organizational development, some organizational diagnosis activities should be implemented to determine the causes of poor safety and productivity practices.

2. Any program to improve safety and productivity should include training and complementary organizational changes aimed at the causes of poor safety and productivity practices.

3. Training should be delivered to all key organizational participants--top management, middle management, firstline supervisors--not just to the miners.

4. Any program to change safety and productivity should be thoroughly evaluated.

ORGANIZATIONAL DEVELOPMENT METHODS FOR INCREASING MINE SAFETY

by

Cecil R. Bell,[1] Martin R. Chemers,[2] and Fred E. Fiedler[3]

ABSTRACT

A demonstration project, funded by the Bureau of Mines, is underway to assess the usefulness and cost-effectiveness of organizational development (OD) approaches for increasing safety and productivity in metal and nonmetal underground mines. The project, conducted at the University of Washington, compares a highly trainer-intensive OD method at the Hecla Mining Co. Star Mine with an approach of considerably less intensive trainer involvement at the soda ash operation of the Texas Gulf Co. in Granger, Wyo.

The trainer-intensive OD method at Hecla uses intensive team building and problem solving, involving participation by top and middle management, as well as by firstline supervisors and work crew members. The less intensive Texas Gulf program emphasizes training in leadership and supervisory skills as well as goal setting activities. It is conducted at the management and supervisory level, and includes top management to foremen and is designed to transfer the required training skills as quickly as possible to company personnel.

The general approach of the project, as well as the contrasting methods used at the Hecla and Texas Gulf mines, is discussed.

INTRODUCTION

OD is a longterm effort that examines and alters management practices and organizational dynamics in a systematic way for the purpose of assisting a company to solve its major problems and to achieve its major goals. The specific techniques include team building, training in leadership and supervisory skills, coaching, counseling of individuals, and feedback of information regarding the status of the organization. The objective of the demonstration project is to ascertain to what extent OD does, in fact, contribute to better safety practices in the metal and nonmetal mining industry.

The project has three major requirements:

1. Conduct an OD demonstration designed to improve mine safety and productivity.

2. Evaluate the effects, if any, the project has on safety and productivity.

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3. Under the assumption that certain features have the desired effects, prepare a package to (a) transfer the features to other mining companies, and (b) leave in place those procedures and techniques that have helped to improve safety and productivity.

As the foregoing comments imply, there are many different approaches to OD, some of which will be more appropriate and cost effective than others in the unique environment of underground mining. It is, therefore, of importance to consider the efficiency of several different methods in order to identify not only those that produce the best results but also those most likely to be acceptable to the mining industry. For this reason we are comparing two distinctly different OD approaches. One of these, at the Hecla Mining Co. in Wallace, Idaho, is a highly trainer-intensive program that follows a classical OD model. The other, at the Texas Gulf soda ash operation in Granger, Wyo., is designed to be trainer nonintensive. The intervention strategies of these two projects differ considerably, as shown in table 1.

TABLE 1. - Comparing two OD approaches

Classical OD, trainer intensive interventions	Modified OD, trainer nonintensive interventions
Organizational diagnosis	Organizational diagnosis
Team building	Leader-match training--all managers
Top management teams	Behavior modeling
Middle management teams	Middle management and foremen using existing modules.
Foreman-crew teams	Development of new safety modules
Foreman human relations skills training.	Goal setting
Intergroup team building	Other interventions as determined by the diagnosis above.
Other interventions as required by the diagnosis above.	

HECLA MINING CO. DEMONSTRATION PROJECT

The Hecla Mining Co., located in Wallace, Idaho, has about 800 employees. It operates two large mines and one small mine, and produces silver, lead, and zinc, with silver being the major mineral of interest. These are deep vein mines with the ore being produced in numerous small stopes going to depths of 8,500 feet. Hecla is viewed by the industry as a successful, well-managed silver mining company.

The program at Hecla is designed as a classical OD intervention. This means it is trainer intensive, focusing mainly on team building and problem solving activities at all levels of the organization. It is organic in that it follows the problems identified and builds tailormade solutions to these problems.

The overall thrust is toward increased safety and organizational effectiveness, to be achieved by systematically focusing on major problems and opportunities. The program components are shown in table 2.

TABLE 2. - Hecla OD activities

Primary activities	Secondary activities
Organizational diagnosis Team building, problem solving Skill training Safety experiments and model building	Organizational effectiveness experiments. Institutionalization and transfer activities.

Team Building

The primary intervention is through team building and problem solving meetings in which a boss and his immediate subordinates identify and resolve major problems whose solution would make the unit more effective. We believe that effective work teams are the key to effective organizational performance.

Some of the assumptions that underlie team building are:

1. Work teams are the basic building blocks of organizations.

2. Effective team functioning requires:

    a. Good leader-member relations.

    b. Clear team goals.

    c. Clarification of role expectations.

    d. Individual and group problem-solving skills.

3. Teams can improve their performance by systematically solving the major problems that confront them.

4. Enhancing work team performance makes individuals more competent and organizations more successful.

Team Building and Problem Solving Activities

Since the major work of an organization gets done by work groups consisting of boss and subordinates, the primary intervention at Hecla is concerned with team building and problem solving at all levels of the organization, starting with the president and his team, and working down to shift bosses and crew teams. The goal is to make each team function better. The means are periodic team meetings addressing the following kinds of questions: What do we do well? What should we be doing better or differently? How can we better accomplish our task or mission? What prevents us from doing the job the way we would like to? How can we improve the work situation?

In a series of meetings, the work group identifies problems and opportunities, prioritizes them, and goes to work on the most important ones. Solutions derived through teamwork are expected to be of generally high quality

because the knowledge and experience of everyone is called upon. Similarly, the solutions have high acceptance and are implemented enthusiastically because everyone has a hand in building them and because everyone understands them.

Team problem solving improves communication and coordination, clarifies who is to do what, and reduces conflicts. All this leads to higher satisfaction of the team members, which should reduce absenteeism and turnover. Team problem solving also leads to technical and organizational improvements for doing the job that can lead to higher productivity and greater safety. The issues to be addressed will be different at different levels of the organization. One issue every team will work on, however, is finding ways to improve safety.

Working with teams rather than with individuals tends to create an organizational climate where people strive toward common, clearly understood goals. Team building and problem solving improve the quality of superior-subordinate communication, whereas skill training improves the competence of individuals and work groups.

Skill Training, Competence Building Activities

Skill training and management development are a second key component of the OD intervention at Hecla. Good intentions for cooperation, delegation, communication, problem solving, etc., are not in themselves sufficient. Good intentions must be coupled with right actions. People are often assigned to jobs for which they may not have the requisite skills. This is especially true in cases of promotion and advancements. The skills that made the individual excel in the old job may not cover the range of requirements of the new job. Identification of requisite skills needed at various levels must be coupled with training to impart these skills. "Ready, willing, and <u>able</u>" is the old cliché.

Training Helps People to Become Able

We expect the skill training needs to be identified during team building at various levels of the organization, but certain training areas appear to be appropriate.

Shift Boss Training

The shift boss, or beat supervisor, is the key link pin between management and the work force. This job is probably one of the most difficult in the entire company. The shift boss must have at least three sets of skills. Technical skills (how to get the job done effectively and safely); human relations, leadership, or people-managing skills; and administrative skills (timekeeping, recordkeeping, etc.). The need for skill building and competence building for the shift boss was mentioned frequently in our diagnosis. These people are often put into their jobs with little or no supervisory training. We believe that shift boss training is an important means to upgrade skills and competence, and should result in greater productivity, safety, and work force satisfaction.

For the human relations part of the training we suggest a behavior modeling approach which has proved especially effective for firstline supervisors. This technique uses short videotapes showing a supervisor effectively dealing with a specific problem. Key behaviors leading to success are highlighted. The videotape is discussed by a group of, say, 10 firstline supervisors. The bosses then role play the situation and obtain feedback on how they did. They practice the behavior back on the job and report in a later class on how it went. The videotape modules, which are now available, address five to eight typical problems of the shift boss such as: dealing with a chronic absentee, counseling and motivating the poor performer, handling a grievance, and enforcing safe practices.

TEXAS GULF MINE DEMONSTRATION PROJECT

The Texas Gulf Corp. is a company with diversified interests in chemicals and mining. Its soda ash operation, located in Granger, Wyo., involves a large and productive underground trona mine. Most mining is done at the 1,370-foot level, on a room-and-pillar basis. About half the work force of some 550 people is engaged in underground operations. Surface operations consist principally of a mill that processes the ore for shipment. The Granger mine went into operation 4 years ago and has worked at capacity since that time. The entire operation is now in the process of expanding to approximately twice its present size.

The OD program at Texas Gulf is designed to increase safety and productivity by means of relatively more structured training approaches that are aimed at the management and supervisory levels and do not require intensive involvement of consultants and trainers. The potential advantage of this approach is its lower cost in consultant and mine personnel time, as well as the relative ease of institutionalizing or transferring the procedures to training personnel of the company. As mentioned earlier, we hope to determine insofar as these studies permit, whether one of the two approaches--the classical trainer intensive OD or the less intensive management training program--yields substantially better results.

Leader-Match Training

This leadership training program is based on the assumptions that the effectiveness of a group or organization depends both on the leader's personality and on the situation, specifically on the control that the situation provides, and that it is easier to change certain critical elements of the leadership situation than to effect changes in the leader's personality or basic approach to others in the work situation.

Leader-match is a 6-to-8-hour training program. It first gives the supervisor or manager information about his own leadership style, specifically whether he tends to be task-motivated or relationship-motivated. It then provides instruction on how to identify or diagnose the leadership situation's major elements, specifically, the leader-member relations, the structure of the task, and the power of the leader's position. Finally, the leader is given very specific training in how to change one or all of the situational

components to match his particular style of leadership. This method has been consistently successful in improving the performance of leaders and managers in a variety of controlled studies in military and civilian organizations.

Behavior Modeling

This method is identical to the behavior modeling approach also discussed in connection with the Hecla project. The training is, however, centered around prepared videotapes which provide models for handling various safety- and production-related supervisory problems. The video presentations are discussed, and supervisors role play and critique one another's attempts to handle a given situation in the training session.

Goal Setting

Specific instruction is provided for management and supervisors in setting precise goals and for planning actions that will enable the group to achieve these goals. Discussions focus on the removal of organizational conditions that prevent the achievement of goals, and specifically on questions of who is to take what action at what time, and who is to determine that such action has been taken and that the next phase of the work, or action to eliminate the next obstruction, has begun.

INSTITUTIONALIZATION

The final task of this project is to determine methods for institutionalizing the various OD and training approaches to assure that the mining industry can take advantage of the findings that result. For this reason we are developing audiovisual aids and instructor manuals that will assist in this process.

We are maintaining an extensive log of innovative procedures introduced by our projects and tracing their acceptance or rejection within the respective organizations. Two examples of institutionalization illustrate this point. The behavior modeling tape describing a mill foreman's concern and insistence on safe working procedures was presented to maintenance foreman at Texas Gulf. Several weeks later, Dr. Chemers was asked by several supervisors if they could show the videotape to all of their mine personnel at the next safety meeting.

A second instance of institutionalization, also at the Texas Gulf mine, concerns the acceptance of leader-match training. Although the training was presented only at the mine in Granger, several personnel and training directors from other Texas Gulf mining properties were invited to view the training. The leader-match training was requested by managers at other mines, and the training director at Granger was given instruction on how to present leader-match training. He is currently engaged in providing training at other Texas Gulf mine properties throughout the organization.

A more systematic effort to ascertain the specific conditions under which various innovative procedures are adopted is in the planning stage and should provide more precise information on this important aspect of our program.

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